Popular Astronomy.

Vol. VII. No. 9. NOVEMBER, 1899. Whole No. 69.

RESULT OF THE OBSERVATIONS OF THE WEATHER BUREAU FOR THE PROBABLE CLOUDINESS OF THE SKY ALONG THE PATH OF THE TOTAL ECLIPSE OF THE SUN, MAY 28, 1900.*

PROFESSOR FRANK H. BIGELOW.

FOR POPULAR ASTRONOMY.

It has been customary for astronomers to examine the meteorological records of the weather conditions prevailing along the path of a total eclipse of the sun, with the view of discovering the most favorable sites for locating stations, in order to avoid as far as possible the cloudiness which is fatal to an observation of the solar corona. Although such an inspection of the prevailing state of the sky in any region affords some average results, this may yet be disturbed by special cyclonic circulations prevailing on the day of the eclipse, and thus become practically valueless as a special long range forecast of the cloudiness. Nevertheless the expense of an astronomical expedition, and the disappointment at failure to see the corona at totality are so great, that they justify these imperfect attempts to forecast the weather. There are in fact certain persistent features in the distribution of the aqueous vapor of the atmosphere as regards a large territory, which is determined by the relative aspect of the oceans, the mountains, plateaus and river basins, so that some districts are actually less disposed to be cloudy at a given season of the year, and hour of the day, than the other parts of the same general region. It is rather with the object of selecting such local positions than of predicting the weather on the day of the eclipse that these efforts are made to survey the track for its average cloudiness. It has been customary to collate the records of such meteorological data as are at hand in the course of the ordinary observations for the region. These were taken without regard to any eclipse work, and since they do not usually pertain to the required hour of the day, they are therefore not strictly applicable. After the West African Eclipse of December 1889, Prof D. P. Todd proposed that special examination along the track be made during the three years pre-

* Published by permission of the Chief of the U. S. Weather Bureau.

ceding the eclipse, at the proper hour of the day, and through the month indicated, so that the data might be of the highest possible accuracy. This program was partially carried out for the eclipse of April 16, 1893, where the track extended from Chili, South America, to Northwestern Africa; also more fully for the Japanese portion of the path of the eclipse of August 9, 1896. The special observations which were taken on those occasions, though somewhat fragmentary, yet proved to be of interest, and at Professor Todd's suggestion the Weather Bureau undertook to collect similar data for the coming total eclipse of the sun on May 28, 1900. In this instance a complete survey of the track has been made in the southern states during the months of May and June, in each of the years 1897, 1898 and 1899. Fortunate the results are of such a character as to render the reports of importance to astronomers, and accordingly a brief account of them is furnished for POPULAR ASTRONOMY. A more complete statement will be found in the reports of the Weather Bureau for these three years.

The observations were divided into two parts, (1) for the "general sky," and (2) for the "sky near the sun." At 8 a. m., 8:30 a. m. and 9 a. m., from May 15 to June 15, inclusive, in 1897, 1898, 1899, observations were made to note the actual cloudiness existing at these hours, the record conforming to the following scale: For the "general sky" the scale of notation was: 0 = sky entirely clear; 1 = sky ¼ cloudy; 2 = sky ½ cloudy; 3 = sky ¾ cloudy; 4 = sky all cloudy. For the "sky near the sun" the scale was: 0 = sun clear from clouds; 1 = sun in scattered clouds; 2 = sun in a mass of clouds; 3 = sun quite invisible. The maximum cloudiness for a single day would be 12 for the "general sky," and 9 for the "sky near the sun," provided each of the three observations showed an entirely overcast sky. For 32 days of observations the maximum sum would be 384 and 288 respectively. Accordingly the sum of the numbers actually recorded for a yearly set of observations divided by these numbers gives the percentage of cloudiness for a station. The stations may be combined by states and the percentages computed in a similar manner. The following table shows the result by states for the three years.

TABLE I.

RECAPITULATION OF THE CLOUD SURVEY FOR THREE YEARS.*

States.	1897.		1898.		1899.		Means.	
	Gen'l Sky.	Sky Near Sun	Gen'l Sky.	Sky Near Sun	Gen'l Sky.	Sky Near Sun	Gen'l Sky.	Sky Near Sun
Virginia	.....	.....	44.9	41.7	35.7	34.3	40.3	38.0
N. Carolina	35.8	33.3	28.2	25.7	33.3	30.6	32.4	29.9
S. Carolina	33.7	32.1	17.5	16.0	28.1	26.7	26.4	24.9
Georgia	18.4	16.0	12.2	10.8	18.5	17.4	16.4	14.7
Alabama	15.2	14.9	17.1	15.7	22.4	22.6	18.2	17.7
Mississippi	.....	.....	23.0	26.4	38.6	31.9	30.8	29.2
Louisiana	26.5	21.5	36.4	30.9	35.9	30.6	32.9	27.7

Table 1 shows several facts very clearly: (1) The minimum of cloudiness is found in the states Georgia and Alabama, and increases thence in both directions towards the coast line, where it is greater than in the interior, and greater near the Atlantic coast in Virginia and North Carolina than near the Gulf of Mexico in Louisiana and Mississippi. This shows that it would be generally safer to locate eclipse stations on the southern elevations of the Appalachian Range, which are from 600 to 1000 feet above sea level where the track crosses them, than in the lower lands nearer the sea coast.

(2) The columns show that the percentages of cloudiness for "sky near the sun" are somewhat smaller than for the "general sky," and from this it may be inferred that the eastern sky is even more favorable at that hour of the morning than the sky as a whole; the fact that the sun will be seen at only a moderate altitude above the horizon does not appear to be an unfavorable circumstance.

(3) Taken as a whole the year 1898 was better than the other years, decidedly better in the interior, and a little worse near the coast, giving a greater range in percentages than for the years 1897 and 1899. In the year 1899 the cloudiness extended more persistently into the interior from the coast in both directions.

(4) The probable percentage of cloudiness for the entire length of the track is about 25% so that the chances are only one to four against astronomers; at the coast line the chances are about one to three against them; in the interior the chances are one to six against them. The favorable chances in the interior are about twice as great as near the coast.

* The figures give percentages of observed cloudiness.

Table II.

Summary of the Survey Along the Eclipse Track for May 28, 1900.

Stations.	The General Sky.				Sky Near the Sun.				Number of Station.
	1897	1898	1899	Means.	1897	1898	1899	Means.	
VIRGINIA.									
Cape Henry	210	204	—	207	115	148	—	132	1
Nimmo	—	—	136	136	—	—	104	104	2
Hampton Inst	—	191	177	184	—	114	109	112	3
Norfolk	172	175	—	174	—	128	—	130	4
Onancock	—	169	80	225	—	118	64	91	5
Birdsnest	—	220	177	199	—	145	125	135	6
Wallaceton	—	177	117	147	—	126	97	112	7
Indika	—	105	—	105	-	59	—	59	8
NORTH CAROLINA.									
Gratesville	184	120	180	161	127	62	135	108	9
Willeyton	162	146	134	147	129	94	95	106	10
Winton	115	59	124	133	72	50	76	66	11
Rich Square	—	—	137	137	—	—	101	101	12
Scotland Neck	—	118	53	87	—	103	39	71	13
Tarboro	162	—	—	162	116	—	—	116	14
Weldon	137	171	187	165	85	117	117	106	15
Rocky Mount	98	165	—	132	66	125	—	96	16
Wilson	117	78	—	98	77	47	—	62	17
Nashville	—	220	132	176	—	155	92	124	18
Spring Hope	189	140	194	174	124	96	122	114	19
Louisburg	134	84	112	110	72	44	68	61	20
Selma	169	63	126	119	128	50	93	90	21
Auburn	134	108	105	116	75	72	68	72	22
Raleigh	192	170	168	177	135	113	122	123	23
Moncure	129	102	82	104	85	73	70	76	24
Pittsboro	150	123	125	133	105	92	95	97	25
Fayetteville	140	108	137	128	104	72	95	90	26
Laurinburg	96	72	—	84	76	58	—	67	27
Rockingham	122	98	123	114	85	25	77	62	28
Albemarle	—	96	101	99	—	49	71	60	29
Wadesboro	85	29	43	52	54	18	32	35	30
Monroe	168	54	82	101	118	28	70	72	31
SOUTH CAROLINA.									
Cheraw	155	101	144	133	114	68	90	91	32
Lancaster	201	95	176	157	125	47	78	83	33
Lewis	—	55	62	59	—	54	54	54	34
Winnsboro	—	—	88	88	—	—	94	94	35
Little Mountain	176	100	123	133	108	59	78	82	36
Santuck	145	51	71	89	99	36	67	67	37
Prosperity	104	54	110	89	82	41	90	71	38
Newberry	—	—	99	99	—	—	68	68	39
Columbia	—	91	152	122	—	67	120	94	40
Chappels	—	69	—	69	—	41	—	41	41
Longshore	—	83	106	95	—	37	65	51	42
Trenton	84	24	72	60	51	15	41	36	43
Cross Hill	90	57	63	70	69	50	54	58	44
Hodges	—	59	—	59	—	40	—	40	45
Greenwood	93	41	82	72	93	27	44	55	46
Saluda	130	82	124	112	90	51	74	72	47
Troy	204	125	-	165	118	65	—	92	48
Watts	117	62	—	90	92	47	—	70	49
Mt. Carmel	91	20	—	56	69	38	—	54	50

Station.	The General Sky.				Sky Near the Sun.				Number of Station.
	1897	1898	1899	Means.	1897	1898	1899	Means.	
GEORGIA.									
Leverett	92	—	—	92	53	—	—	53	51
Carmak	61	30	—	46	44	21	—	33	52
Elberton	42	—	—	42	33	—	—	33	53
Crawfordville	133	74	—	104	80	17	—	49	54
Athens	88	55	57	67	51	26	40	39	55
Macon	—	27	—	27	—	24	—	24	56
Covington	78	24	—	51	62	57	—	60	57
Atlanta	—	80	91	86	—	58	72	65	58
Griffin	—	40	84	62	—	24	66	45	59
Talbotton	91	65	97	84	38	22	48	36	60
Westpoint	35	21	45	34	27	10	31	23	61
Columbus	30	64	53	49	25	50	44	40	62
ALABAMA.									
Smith's Station	63	53	95	70	52	43	61	52	63
Fort Mitchell	82	87	101	90	55	60	74	63	64
Auburn	57	67	117	80	49	53	93	65	65
Opelika	—	—	86	86	—	—	85	85	66
Lochapoka	56	72	—	64	34	36	—	35	67
Tuskegee	—	—	110	110	—	—	120	120	68
Union Springs	85	57	72	71	63	60	71	65	69
Tallassee	70	83	111	88	57	62	81	67	70
Matthews	48	45	72	55	40	32	47	40	71
Troy	—	—	85	85	—	—	53	53	72
Montgomery	49	62	98	70	41	51	79	57	73
Highland Home	25	54	53	44	10	18	28	19	74
Ft. Deposit	24	40	66	43	19	20	55	31	75
Greenville	28	35	64	42	26	14	33	24	76
Pine Apple	61	105	—	83	52	103	—	78	77
Castleberry	63	42	69	58	55	40	55	50	78
Latham	45	48	54	49	20	16	37	24	79
Bay Minette	110	58	76	81	74	62	60	65	80
Mount Vernon	62	135	113	103	53	84	67	68	81
Mobile	73	99	—	86	43	35	—	39	82
Citronelle	64	59	110	78	31	27	73	44	83
MISSISSIPPI.									
Leaksville	—	46	—	46	—	47	—	47	84
Americus	—	120	60	90	—	105	60	83	85
Ocean Springs	—	24	112	68	—	18	80	49	86
Biloxi	—	114	129	137	—	71	81	76	87
Bay St. Louis	—	126	170	148	—	27	93	60	88
Pearlington	—	115	86	101	—	167	147	157	89
LOUISIANA.									
Poydras	139	133	—	136	40	54	—	47	90
New Orleans	109	187	144	147	56	89	59	68	91
South'n Univ. F'm	—	127	—	127	—	80	-	80	92
Houma	59	141	123	108	31	86	102	73	93
Schriever	—	—	102	102	—	—	91	91	94
Napoleonville	—	144	—	144	—	89	—	89	95
Paincourtville	114	109	100	108	86	92	71	83	96
Centreville	65	—	146	70	61	—	103	82	97
Franklin	148	163	159	157	98	129	103	110	98
Elm Hall Plain	—	—	190	190	—	—	87	87	99

Total number of observing stations, 99.
Number of stations in 1897, 66.
" " " " 1898, 86.
" " " " 1899, 74.
Number observing 3 complete series, 47.
Stations in heavy faced type are quite near the central line of the eclipse.

A more detailed exhibit of these observations is shown on Table 2, which gives for every station, under the two specified headings, "general sky" and "sky near the sun," the sum of the clouds observed on the adopted scale for the 32 days required. Thus for Cape Henry in 1897 the sums are 210 and 115 out of a possible 384 and 288 respectively; in 1898 they are 204 and 148; in 1899 they are missing. It is impracticable to print *in extenso* the complete daily record with the attached notes. The last column contains an assigned station number which can be entered on the eclipse chart at the proper latitude and longitude as an abbreviation. The stations printed in heavy faced type are located quite near the central line of the eclipse, and are well situated, so far as that goes, for seeing the eclipse with a considerable duration of totality. By studying this table some notion may perhaps be gained of the relative freedom from clouds of stations in nearly the same region, as for instance within a single state.

The significance of Table 2 may be seen by refering to Chart 1, where the numbers from the column of the mean for the three years, and for "sky near the sun," are plotted in a diagram. The axis of abscissas represents the central line of the shadow path from Louisiana on the left to Virginia on the right. The location of an individual station in relative longitude having been taken on this axis, an ordinate point is plotted at the height of the resulting observed average cloudiness, on the arbitrary scale shown at the margins. Near this point is placed the station number from Table 2, so that in effect the last two columns of that table are transferred to Chart 1. The omitted stations can be added readily, if any one desires to do so for the sake of further comparisons, but as they lie nearer the edge of the path of the shadow, the duration of totality will be proportionally shortened for them.

It is seen from Chart 1 that the line of aver ge cloudiness, which was drawn in by free hand, has its minimum in Georgia and Eastern Alabama, and that its ends have the maxima, that on the east being greater. Station (89) Pearlington, Miss., has 2 years of observation, but its eastern horizon is not good; station (68) Tuskegee, Ala., has only one year's observations and it may have been less favorable than usual. The other stations show only such a variation from the mean as may be ascribed to personal equation in estimating the cloudiness, or else to certain local conditions. If all other things are equal the stations plotting above the line are less favorable than those below it. The Alabama stations make an especially good showing.

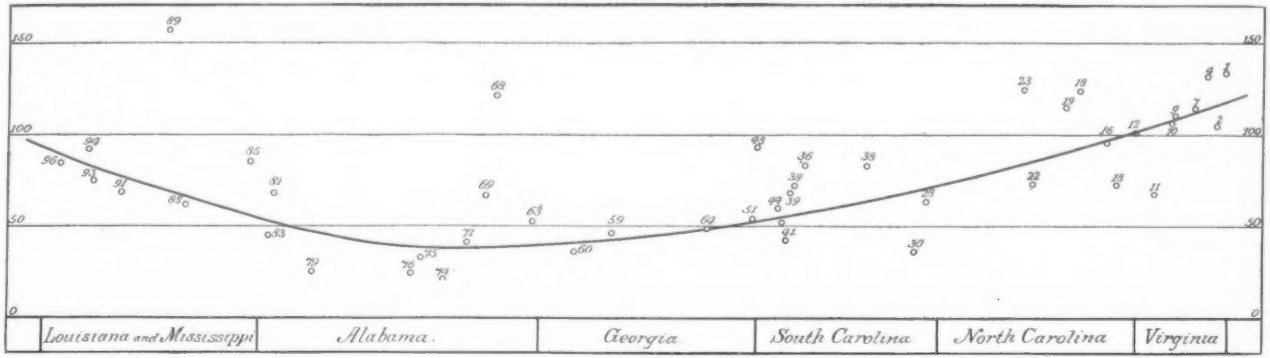


CHART I.

THE MEAN RELATIVE CLOUDINESS "NEAR THE SUN," AS GIVEN IN TABLE 2, FOR STATIONS QUITE NEAR THE CENTRAL LINE OF THE SHADOW.

A diagram of the eclipse track has been plotted throughout its course over the East Gulf and Middle Atlantic, from the astronomical data of the American Nautical Almanac. On it have been placed some of the stations given above and the location of the other towns and cities may be found by referring to a large map. The scale of the chart is rather small, but it is sufficiently accurate to show the visiting astronomers where to undertake their operations.

The lines crossing the track on Chart 2, and numbered from 1 to 6, refer to the places where data of the American Nautical Almanac applies, giving the local times and duration of totality at certain epochs.

1.	At	7h	27m.4	a. m.	Local	M.	T.	the duration is	1m	12s.6.
2.	At	7	47.1	"	"	"	"	"	"	1 19.6.
3.	At	8	5.2	"	"	"	"	"	"	1 26 0.
4.	At	8	22.2	"	"	"	"	"	"	1 31.7.
5.	At	8	39.5	"	"	"	"	"	"	1 37.0.
6	At	8	54.2	"	"	"	"	"	"	1 41.9.

Since the duration of totality increases towards the east and is greatest near the Atlantic coast, astronomers would naturally choose their stations in that region. Unfortunately that is also the place where the maximum of cloudiness is to be anticipated, and consequently there must be some balancing of chances in making the selection between these two circumstances.

It is by no means implied that other sites along the track are not equally good for observing the eclipse, and it is probable that there are many such. The stations recorded in this paper are only those which have taken part in the Weather Bureau Survey, and therefore pertain especially to this discussion. The Chief of the Weather Bureau sent a circular letter to a number of towns located near the central line, requesting replies to several questions of interest to astronomers, in order that such practical information might be furnished them regarding the localities as would assist in deciding upon the best sites. The questions concerned the latitude, longitude, altitude, population, accommodations, railroads, topography, eastern horizon, wind and drift of smoke, and suggestions regarding good sites accessible to heavy baggage. The replies of 37 places are summarized in the Report of the Weather Bureau for 1899, to which those interested are referred. The astronomers of the United States and foreign countries will appreciate the assistance which so many volunteer observers have cheerfully rendered in making this survey as complete as possible.

REPORT OF THE BOARD OF VISITORS TO THE UNITED STATES NAVAL OBSERVATORY, OCTOBER 2, 1899.

FOR POPULAR ASTRONOMY.

WASHINGTON, D. C., Oct. 2, 1899.

HON. JOHN D. LONG,
Secretary of the Navy.

SIR:—In compliance with the request contained in your letter of June 30th, 1899, the undersigned have acted as a Board of Visitors to the United States Naval Observatory in Washington and now submit their report, including subdivisions as follows:

I. Recommendation of the Board of Visitors.
II. Circumstances leading to the appointment of the Board of Visitors.
III. Cost of the Observatory.
IV. Comparison with other Observatories.
V. Present condition and methods of Observatory work and the delay in printing its results.
VI. Historical sketch of the Observatory.
VII. Minutes of the proceedings of the Board of Visitors.
VIII. Appendix.

The several portions of the report were put in form by the astronomers who are members of the Board. The recommendations are made unanimously.

Very respectfully,
WM. E. CHANDLER,
A. G. DAYTON,
EDWARD C. PICKERING,
GEO. C. COMSTOCK,
GEORGE E. HALE.

RECOMMENDATIONS OF THE BOARD OF VISITORS.

In accordance with the instructions contained in the following letter all the members of the Board of Visitors to the United States Naval Observatory therein named met at the Observatory in Washington on Friday, June 30, 1899, and organized by the selection of William E. Chandler as Chairman and George C. Comstock as Secretary.

NAVY DEPARTMENT,
WASHINGTON, June 30, 1899.

GENTLEMEN:—In accordance with previous correspondence and oral conversations, you are hereby requested to act as a Board of Visitors at the United States Naval Observatory in Washington, convening there today, and to proceed to examine into the condition of that institution and to report to me your conclusions and recommendations.

Very respectfully,
JOHN D. LONG,
Secretary.

HON. WILLIAM E. CHANDLER,
HON. ALSTON G. DAYTON,
PROFESSOR EDWARD C. PICKERING,
PROFESSOR GEORGE C. COMSTOCK, AND
PROFESSOR GEORGE E. HALE.

Captain Charles H. Davis, U. S. N., Superintendent of the Naval Observatory, presented to the Board an informal statement of circumstances leading to the appointment of the Board of Visitors and submitted correspondence relating thereto (Appendix, Exhibit A.) and to a proposed reorganization of the Observatory (Appendix, Exhibit B.). He also placed before the Board a list of Professors of Mathematics upon the active list of the Navy (Appendix, Exhibit C.) from which corps the staff of the Observatory is largely drawn, and a list of all persons performing duty at the Observatory with their respective ranks (Appendix, Exhibit D.).

At the request of Messrs. Chandler and Dayton there was submitted to the Board by its other members the correspondence conducted by them as a Committee of the Second Annual Conference of Astronomers and Astrophysicists for the purpose of obtaining the views of American astronomers and physicists upon the organization and work of the Naval Observatory. Mr. Pickering submitted to the Board a statement regarding correspondence on the same subject conducted by a Committee of the American Association for the Advancement of Science.

In view of the facts brought before the Board at its several sessions and after the best consideration which it has been able to give to the subject, the Board of Visitors reports and recommends as follows:

The Naval Observatory, which was originally established as a scientific bureau, auxiliary to the needs of the naval service, has become through half a century of growth and through the expenditure of large sums of money, as authorized by law, an astronomical Observatory of the first rank in respect of buildings, instruments and equipment. But by far the larger and more valuable part of its equipment has little or no reference to any direct requirement of the naval service and its existence can be justified only on the ground that Congress has intended to establish and maintain a national astronomical Observatory. Under these changed circumstances its continued connection with the Navy Department has seemed to many of those whose views have been submitted to the Board of Visitors, illogical and undesirable. In view, however, of the absence of a national university, a Department of Science and Industries, or other department or bureau of the government especially suited to the conduct of such scientific work, and in view of the diversity of opinion among American astronomers upon the question to which existing department the Observatory could be wisely

transferred, we believe it to be inexpedient for us at the present time to further consider the subject of such transfer.

With reference to the organization of the Observatory under naval administration, the Board of Visitors, disapproves of those parts of the "Proposed Organization of Naval Observatory" (Appendix, Exhibit B.), submitted under date of September 7, 1897, by "F. E. Chadwick, Chief of Bureau of Equipment and C. H. Davis, Superintendent U. S. Naval Observatory," which require the establishment of a formal observatory council with nominal functions and which by omission practically abolish the office of Astronomical Director. We are by no means objecting to the assembling in conference of the astronomers engaged in observatory work, but the proposed transfer of duties and responsibilities from a single director to a committee of five appears to us a step in the wrong direction; and when, as under the proposed scheme, an absolute power of veto upon all action by the council is lodged in the hands of one of its members, the usefulness of the body seems to approach the vanishing point. In the history of Observatories we have been unable to find a case of successful administration without a competent astronomer in immediate supervision of the work and we believe that the ideal conditions for the successful administration of an astronomical Observatory are most nearly realized when a professional astronomer is made the responsible director of the work. This system, which is adopted in every great national Observatory, the Board of Visitors believes to be the one best suited to secure the astronomical efficiency of the Naval Observatory.

If the Observatory as a shore-station charged with the performance of certain functions assumed to have a relation to the navy is to continue under the command of a line officer, we recommend that the astronomical staff of the Naval Observatory shall consist of an astronomical director, four astronomers, three assistant astronomers and such computers and other minor officers as may be provided by law. The astronomical director and astronomers, whether professors of mathematics or taken from civil life, and the assistant astronomers, should be appointed by the President, by and with the advice and consent of the Senate, to hold their offices until their successors are appointed.

The Nautical Almanac office, which was formerly a distinct bureau, is now administered, by departmental regulation, as a part of the Naval Observatory and it appears from the evidence submitted to the Board of Visitors that the successful adminis-

tration of the Observatory is much impeded by reason of imposing upon its astronomical director the duties of director of the Nautical Almanac. Each of these offices furnishes abundant employment for the entire time of an able astronomer and we therefore recommend that there shall be a director of the Nautical Almanac appointed by the President, by and with the advice and consent of the Senate, to hold office until his successor is appointed.

We also recommend that provision be made for the continuation of the admirable series of memoirs published under the title "Professional Papers of the American Ephemeris and Nautical Almanac."

A criticism, frequently and forciby urged against the administration of the Naval Observatory, not limited to the present time but covering almost the entire period of its existence, is that its astronomical work has not been prosecuted with that vigor and continuity of purpose which should be shown in a national Observatory. The possibility of conducting well planned researches with unvarying regularity over long series of years should constitute the great advantage of a national Observatory, an advantage which is not fully realized in the history of the Naval Observatory, where each principal astronomer seems to have been left to choose his own line of work and to alter it from time to time or abandon it. This is perhaps inevitable in a system which places at the head of an Observatory an officer who is not a technical expert in astronomical work; and therefore in order to secure continuity in the prosecution of work well chosen and co-ordinated with that of other Observatories, and also to obtain for the Observatory and the department advice and criticism which shall be both disinterested and responsible, we recommend the establishment of a permanent Board of Visitors substantially as follows:

There shall be appointed by the president, from persons not officers of the United States, a Board of nine visitors to the Naval Observatory, six to be astronomers of high professional standing, and three to be eminent citizens of the United States. Appointments to this Board shall be made for periods of three years, but provision shall be made by initial appointments for shorter terms so that two astronomers and one member of the board not an astronomer shall retire in each year. Members of this Board shall serve without compensation, but the Secretary of the Navy shall pay the actual expenses necessarily incurred by members of the Board in the discharge of such duties as are assigned them by

the Secretary of the Navy, or are otherwise imposed upon them. The Board of Visitors shall make an annual visitation to the Naval Observatory at a date to be determined by the Secretary of the Navy and may make such other visitations, not exceeding two in number annually, by the full Board or by a duly appointed committee, as may be deemed needful or expedient by a majority of the Board.

The Board of Visitors shall report to the Secretary of the Navy at least once in each year the result of its examinations of the Naval Observatory as respects the condition of buildings, instruments and apparatus, and the efficiency with which its scientific work is prosecuted. The Board of Visitors shall prepare and submit to the Secretary of the Navy regulations prescribing the scope of the astronomical and other researches of the Naval Observatory and the duties of its Staff with reference thereto. When appointments or details are to be made to the office of the astronomical director, astronomer or assistant astronomer in the Naval Observatory, the Board of Visitors may recommend to the Secretary of the Navy suitable persons to fill such offices, but such recommendations shall be determined only by a majority vote of the members present at a regularly called meeting of the Board held in the city of Washington.

Special attention is at this point called to the fact that the appointment of a Board of Visitors to the Naval Observatory was recommended by Secretary Tracy in 1891, has been repeatedly urged by superintendents of the Observatory, and is renewed by F. E. Chadwick, Chief of Bureau of Equipment, and C. H. Davis, Superintendent U. S Naval Observatory, in the "Proposed Organization of a Naval Observatory," dated September 7, 1897, (Appendix, Exhibit B). The duties of the Board, as defined by these naval officers, would be in part as follows: "It lays down the general course of policy to be pursued for the coming year, including printing and publication of observations; fixes the estimates for the astronomical departments; nominates to fill vacancies in the astronomical staff (either by appointment or promotion); recommends as to repairs and acquisitions of new instruments.

If a permanent Board of Visitors as above recommended is established as a part of the administration of the Naval Observatory it is evident that to it should be committed those questions of policy to be pursued in the conduct of the Observatory which are contained in the memorandum (Appendix, Exhibit B.) submitted to the present Board by the Secretary of the Navy under

date of June 28, 1899. We therefore abstain from specific recommendations upon these subjects, many of which indeed call for a more prolonged and minute study of the situation than the members of the present Board have been able to give to it.

We heartily endorse the recommendation contained in your report as Secretary of the Navy for the year 1897, that "the statute authorizing the appointment of professors of mathematics be so amended that without disturbing those who now hold office, which would be unjust to them, no further appointments shall be made" to the staff of the Naval Observatory (Appendix, Exhibit L). In addition to the reasons for this action which are urged by you in that report, we submit for your consideration that the conditions under which astronomical work is done are so different from those which obtain in the naval service that a fixed tenure of office with the certainty of a retiring pension in no way dependent upon the zeal or efficiency with which service has been rendered may easily produce diminished diligence and a purely perfunctory discharge of duties. A more serious evil of the existing system of naval commissions for astronomers, and one which has been forcibly exemplified within the past decade, is the compulsory retirement at the age of 62 of astronomers who are then in the maturity of their powers and who under civilian appointments would continue to render to the Observatory a service of undiminished efficiency which they now transfer to other institutions. The reasons which impel the retirement of a naval officer from active service upon attaining a fixed age have no application in the case of an astronomer, and he should be placed upon the same footing with other officers of the government performing strictly civilian duties.

If astronomers are appointed to the Naval Observatory from civil life to succeed retiring professors of mathematics the salaries provided should be sufficient, as recommended by you in that report of 1897, "to make up for the refusal to them of the privilege of retirement and also to secure men of high scientific attainments adequate to the demands of one of the most capable observatories in the world." To secure the services of the ablest astronomers the salaries provided should be slightly larger than those paid in the higher class of university Observatories and account should be taken of the fact that university vacations are much longer than leaves of absence from public service. The Board of Visitors recommends the following as a schedule of sal-

aries which could be expected to attract astronomers of the class desired:

Astronomical Director	$6,000
Director of Nautical Almanac	5,000
First Astronomer	4,000
Second "	3,600
Third "	3,200
Fourth "	2,800
First Assistant Astronomer	2,400
Second " "	2,200
Third " "	2,000

The experience of every great Observatory shows that the efficiency of its staff is materially increased by the provision of quarters near the observing rooms for those persons who are engaged in work by night, and we recommend that there should be quarters provided upon the observatory grounds for all members of the astronomical staff regularly assigned to night work.

In concluding its recommendations the Board of Visitors wishes earnestly to urge upon your consideration the necessity of making a success of the movement which you have begun in order to improve the condition of the Naval Observatory and to make its administration satisfactory to the great body of the astronomers of the country and to the public.

Some of our recommendations if they meet your approval can be carried into effect by departmental action, but the changes which we regard as vital can only be obtained through legislation by congress. If such legislation is withheld, the continuance of present conditions is sure to result in a renewed, persistent, and possibly acrimonious demand for the removal of the Observatory from naval control. If, however, the legislation is enacted, and the improved system is given a fair trial, unquestionably much improvement will result and it is not improbable that the Observatory will attain and hold that high standing in the scientific world which should be required of such an institution.

To help bring about such a desirable consummation we have complied with your request, although not made in pursuance of any law, that we should visit and investigate the Observatory, and we have recommended specific measures which we hope will lead to those reforms in administration which are imperatively necessary if the Observatory is to receive and retain the confidence and support of the astronomers and scientists of the world.

THE PLANET MERCURY.

W. W. PAYNE.

In May, 1897, Percival Lowell presented to the American Academy of Arts and Sciences a memoir entitled new observations of the planet Mercury. It appeared in printed form June, 1898, though we did not see a copy of it until August, 1899. We have read the paper and find in it so many things of interest, and in our judgment, of real value, that we present to our readers a pretty full review of it.

By way of introduction we wish to say that we have very little patience with that supercilious, astronomical cant that has gained so much currency in scientific circles during the last five years, regarding the trust-worthiness of Mr. Lowell's observations and the opinions he has formed from them. Our readers know already what we think of the attitude that some astronomers have taken with regard to Mr. Lowell's work in condemning it, because they cannot see as much as he does. Mr. Lowell has probably made mistakes in both directions. What astronomer, worthy of the name, because he has attempted new and difficult work, has not made errors. That grand old hero of celestial spectroscopy who still works on the other side of the sea once thought there was water vapor in the atmosphere of Mars. Who blames him now because he honestly thought so, years ago, notwithstanding astronomers on this side, with better spectroscopes, do not find evidence of it? Again, the worst thing about these hasty, severe and unwarranted judgments of men of science is their influence on the student and the young astronomer. As a consequence, some of these classes are constantly held back from presenting good work, simply because they fear criticism that will hold them up to ridicule. This may be the best way to deal with "cranks," so-called, and the like.

Mr. Lowell began observations on the planet Mercury in the autumn of 1896, with a Clark 24-inch telescope for a study of the planet's rotation period. He was assisted by Mr. D. A. Drew and Miss W. L. Leonard. From the first the markings on the surface were easily seen in daylight observations if the condition of the atmosphere was favorable. In this connection he gives some experience in regard to the use of telescopes of large aperture and the necessity of keen vision to detect the markings on the surface of the bright planet Mercury. After trying telescopes whose apertures range from 4 to 24 inches, and after the com-

parison of the powers of many different eyes, Mr. Lowell claims that the results obtained are not necessarily due either to large telescopes or to the practiced or keen eye. This is interesting especially when we remember how much was said against Schiaparelli's work on Mars in 1889 and later because he saw so much with a telescope of only seven inches clear aperture. Mr. Lowell's own words put this point well. He says:

"At times a small aperture is better than a large one, at other times not, the relative efficiency of the glass depending upon the condition of the air. In Mexico I was able to test this very effectively by having the 6 inch clamped on the 24-inch tube, so that it shared the advantage of the other's mechanism, and, what is vital in such a test, it enables the two images to be compared at almost the same instant by the same eye. I found that the performance of the 6-inch was nearly equal to that of the 24-inch; that on the average it revealed almost as many markings as the larger glass; and that when the two differed in efficiency it was apparently a question of the kind of air-waves prevailing at the moment. In the moments of best seeing, the 24 inch of course distanced its competitor; but the detection of the principal markings does not demand superiority of this sort."

Another point is made in this connection that is quite as important as the one just referred to. It is regarding keenness of vision. Mr. Lowell claims that there is no such difference between fairly normal eyes and those of skillful observers, as many have been led to think. By some careful study of this point he concludes that one eye is just as good as another after some practice in a particular line of observation. He says "it is not keenness of sight, but keenness of brain that distinguishes the good from the poor observer. It is with astronomical observation exactly as it is with every-day affairs. The able observer is he who perceives what any one else may see." This will certainly be an encouraging thought to the average amateur if he does not regard the limitation of "keenness of brain" as a more difficult factor than the other in the make-up of ordinary observers. Hence, good results in astronomical work do not so much depend on the eye or the aperture of the telescope, as on the condition of the air when the observations are made and the patience and the persistence of the observer in doing his work.

In the observations of the planet Mercury, Mr. Lowell makes another point of interest; it is the fact that his observations were made almost wholly by day and as near noon as possible. In this way he was able to follow the planet almost to superior

conjunction, showing that the best time to observe it is when the almanacs say "Mercury invisible during the month." The eye-pieces used were those of low power, the high powers failing to give satisfactory results, even the lowest commonly used on large telescopes.

Those magnifying only 135 to 170 were most satisfactury on the 24-inch telescope and 75 to 135 on the 6-inch instrument. If the air was steady a power of 300 on the 24-inch glass showed the markings on the planet fairly well. To get the advantage of seeing much of the detail of surface markings, it is necessary to be persistently patient in looking for them. Steady air will not long remain so. One may have to wait long for the good moments that reveal the clear-cut views that always astonish and delight the observer, while he wonders why he has not seen those details before.

Mr. Lowell's remarks on these points remind us of the way Schiaparelli worked in 1888 and later while studying the surface markings of the planet Mars. Because he used a small telescope and observed in daylight, it was thought by some that it would certainly be impossible to get anything comparable with the results obtained by large telescopes used at night when Mars is in favorable position. The work of Schiaparelli, as astronomers now know, was so successful as to be a total surprise to everyone. It could not be believed at first because it so completely reversed commonly approved methods that no one could have confidence in the new ways employed.

The details of observation and measurement of markings on Mercury employed by Mr. Lowell are as interesting to the student as are the results obtained. The filar micrometer was used in preference to the double image micrometer because the latter instrument was deemed less accurate than the former. This view is contrary to that given by astronomers of high authority, and hence should receive careful attention in the future, to determine who is right. The reasons offered for this belief, by Mr. Lowell, are that the double image micrometer does not reduce irradiation as much as supposed,—not even more than the filar micrometer does on an image of the same brightness; and the distinct disadvantage is that the image formed by the double eyepiece is in greater distortion and flare which render "the measures less reliable."

The work done in the planet's surface is spoken of under two heads: (1). The drawings of features on the surface. (2). The micrometric measures of the planet's diameters and the discussion of the same.

Three hundred and eleven drawings and twelve sketches were made of the planet's disc. One hundred and four of these and five sketches were made at Flagstaff, and two hundred and seven sketches, at Mexico. These markings were seen and drawn by each of the six different members of the Observatory, through two different telescopes, the 6-inch and the 24-inch, while the Observatory was located at the two places named above. In this work the planet was watched from its place near inferior conjunction when it could be first seen to that of the disc nearly full, as it approached superior conjunction. Mr. Lowell says the planet was followed to within 4° of the Sun, and that he then stopped observations only because he wished to remove the Observatory from Mexico back to Flagstaff. If the object glass is screened, as much as possible, from the direct rays of the Sun, the observer can follow the planet easily when near the Sun.

After the observational work is completed, reduced and tabulated, then follows the discussion involving many points of general interest.

The rotation period of Mercury is first considered. From markings on the surface distinct and permanent, which were always seen when the atmosphere was steady and more or less according to its steadiness, it is shown that the rotation period around an axis perpendicular to the plane of its orbit is synchronous with its orbital revolution. From a study of the observations and drawings, Mr. Lowell claims that the short period of rotation corresponding nearly in time to one of Earth's days can not be sustained, but that the observations are satisfied by the long period named above. The point is confirmed in an interesting way by the measures of the libration in longitude which the surface markings show as compared with the terminator. If the planet rotates uniformly in any period of time, its variable velocity in its eccentric orbit must show large libration at maximum, which Mr. Lowell gives 23° 40′ 38″. Now, as this variable libration in different parts of the orbit corresponds with the long period of rotation, it strongly supports that period as the true one. The computations given by which this result is obtained are easily followed and may be read by students having but little of the so-called higher mathematics. Table I showing the phase angle and the angle of libration for every day from Feb. 4 to March 28 is given in connection with this proof. Another proof of the time of rotation is drawn from the observations of a surface-marking called, now, Testudo-Regio, in former papers by Mr. Lowell, Argi-Rigio. Observations of this were made in 1896

from Oct. 28 to Nov. 28, and in 1897 from Feb. 7 to Feb. 15. The result of this shows the long period of rotation to be the true one.

The detailed description of the surface-markings indicates the definiteness of observation already spoken of, and shows that the particular part of the planet turned towards us has a cloudless sky, apparently invariable. The markings appear on the pale white surface in dark relief, which is in marked contrast with the shades of red, blue and green that are so common on the surface of Mars. There are no polar caps, and none of the effects that follow from the presence of an atmosphere so far discernable. It also seems probable that there are no bodies of water on the surface, no vegetation, no perceptible change in any important particular. The one suggestion that comes from all this is that Mercury like the Moon is a dead world.

Mr. Lowell calls attention to brightness of the limb for some time before and after the phase which shows half of the disk, as well as the shadings at the cusps. Further on in the paper, he offers some reasons for the phenomena. Next he gives an interesting paragraph on the albedo of the planet. By albedo is meant the power of the surface to reflect the light of the Sun that falls upon it. During the observations of the two planets, Venus and Mercury, when near together Mr. Lowell finds that Mercury is "strikingly not so bright in albedo as Venus, although at this time Mercury was nearer the Sun in proportion of 100 to 165, and hence should receive 2.73 times as much light per square unit of surface as that received by Venus.

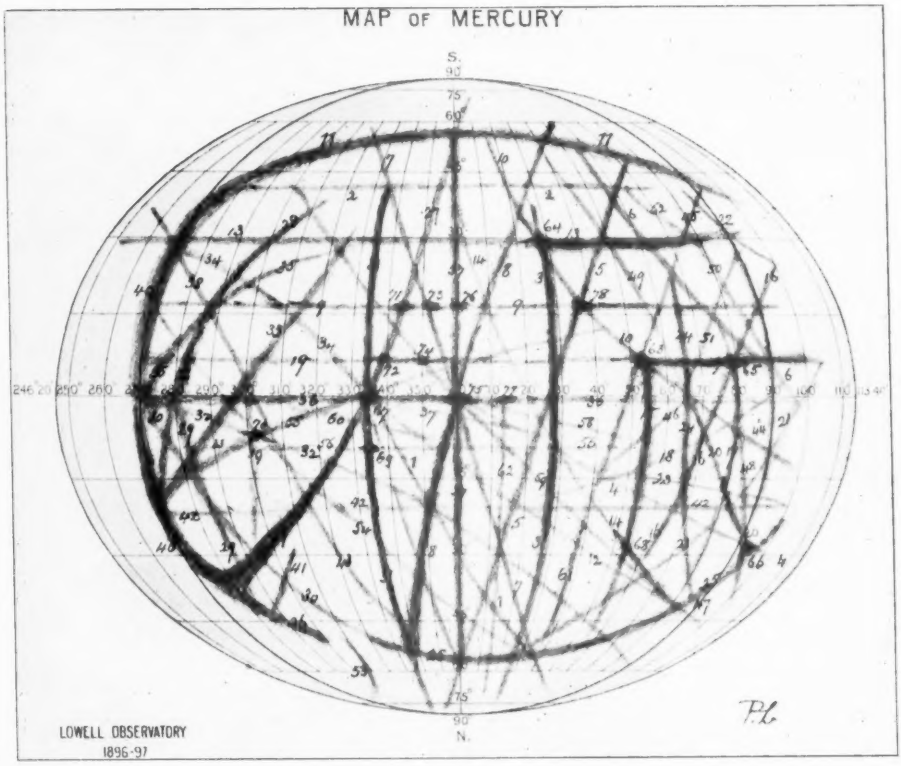
Several other interesting details are mentioned which the reader will find quite fully stated in this valuable paper. We present with this review the diagram which gives full illustration of the markings described in this paper. We are sure it will be studied with interest. We also give below a brief Summary of the paper in Mr. Lowell's own words, following this by the index to the plate.

SUMMARY.

"(1) A body somewhat larger than has been supposed; its polar diameter subtending at distance unity about 7″.50, equivalent to about 3,400 miles. From the difficulty of evaluating the irradiation I consider that this is probably too large, and that 3,300 miles is nearer the truth. The older measures, however, are certainly too small.

(2) Of a probable density much less than the Earth's, and according, within errors of observation, with what *a priori* principles of size and solar position would lead us to suppose;

PLATE XI.



(3) Of a probable mass, from (1) and (2), between the older and later determinations,—about $\frac{1}{20}$ of the Earth's;

(4) Rotating in 87.969 days, its orbital period. The decimal is here given because though the period of rotation my differ by a minute amount from the orbital period, no such deviation has been observed and it is very unlikely that any exists; especially as

(5) There seems to be evidence that it has rotated thus from the time it was plastic;

(6) About an axis approximately perpendicular to the plane of its orbit;

(7) Possessing no certain signs of atmosphere;

(8) Nor sign of water;

(9) Nor of vegetation;

(10) Nor of organic life;

(11) Covered with long narrow markings best explained as the results of cooling;

(12) Somewhat symmetrically disposed, thus suggesting (5);

(13) A world as dead as the Moon, but differently brought to such condition.

INDEX TO PLATE.

1. Maia.
2. Hypate.
3. Zugon.
4. Thoth.
5. Oneiraton.
6. Ala.
7. Cyllene.
8. Psychopompos.
9. Lichanos.
10. Petasus.
11. Keras.
12. Agetor.
13. Parhypate.
14. Hegemonios.
15. Enodios.
16. Agoraios.
17. Caduceus.
18. Empolaios.
19. Mese
20. Anguis.
21. Serpens.
22. Keryx.
23. Diemporos.
24. Pedilla.
25. Cornu.
26. Talaria.
27. Plectron.
28. Ebur.
29. Corneus.
30. Somnus.
31. Oneiropompos.
32. Poimandres.
33. Psychagogos.
34. Trismegistos.
35. Aphorismos.
36. Paramese.
37. Kuranides.
38. Smaragdina.
39. Chlamys.
40. Testudo.
41. Pteron.
42. Paranete.
43. Nomios.
44. Dolios.
45. Lichanos.
46. Sokos.
47. Pheneos.
48. Phara.
49. Pelene.
50. Carvara.
51. Kephalos.
52. Hegemonios.
53. Vayu.
54. Turms.
55. Necropompos.
56. Trite.
57. Hermes.
58. Boukolos.
59. Kriophoros.
60. Polygios.
61. Promaxos.
62. Sarameya.
63. Mese meson.
64. Parhypate hypaton.
65. Mese hypaton.
66. Nete hypaton.
67. Paramese hypaton.
68. Nete meson.
69. Trite diezeugmenon.
70. Trite hyperbolæon.
71. Lichanos hyperbolæon.
72. Mese hyperbolæon.
73. Lichanos synemmenon.
74. Mese diezeugmenon.
75. Paramese meson.
76. Lichanos meson.
77. Paramese hypaton.
78. Lichanos hypaton.

The names have been given in accordance with the suggestion of the markings themselves whose outline is singularly like the

tortoise-shell lyre invented by the god; the lines along the parallels of latitude being the strings and the conspicuous marking 29 representing the plectron."

ASTRONOMY BY THE LABORATORY METHOD IN SECONDARY SCHOOLS.

For Popular Astronomy.

If by the laboratory method is meant such observation and investigation of selected phenomena pertaining to any subject as shall yield to the student an abundance of essential facts; if it mean that from the many such related facts reasonable explanations of these phenomena may be expected from the student who thinks simply and logically; if it be a manner of so presenting a subject through its phenomena to the mind of a student that he may reach out towards conclusions of a general nature, to the principles and laws which pertain to that subject, as a direct sequence of his own observations and thought processes,—if these be the aims of laboratory methods of teaching, then astronomy may be thus taught, and demands such manner of presentation to the students of our secondary schools.

It is far from our purpose to pose as an instructor in pedagogy, or to enter upon any psychological discussion whatsoever. Yet it were pardonable, surely, to restate as a cardinal principle of educational work that mental growth results only from mind activity rightly directed. As the highest and best of the physical being demands that every muscle have its exercise and development, so the mind in its every capacity is to be exercised.

One stage in the development of the science of education was content to have the student memorize the words of the text regardless of any full comprehension of the thought expressed therein. It was a great step in advance when mastery of the thought of the author was made of prime importance, and the expression of that thought in the words of the student himself was encouraged or required. There remained a single step further, and with many a teacher it has yet to be taken in the full round of the science work, the *requirement of original thought from the student* as well as original expression of thought. To require of students in our secondary schools in the study of any science nothing further than mastery of the thought of an author as expressed in the text-book is neither the most complete nor the most profitable mental activity.

Allowing that we have in books veritable storehouses of the riches of ages of human experience—thoughts that are profound, language that is grand, thought expressions to whose depths and to whose heights we may scarcely hope to attain, expressions that may tax to the uttermost our endeavors of a life-time to rethink them, humble travelers as we are over well marked mental highways and byways—allowing all this, it is contended that the great mass of books put into the hands of our students *are not of this character*, and that the writers of modern text-books for secondary schools are few who seek to do other than to put before the student in the simplest, most elementary manner possible the facts of the subject treated. It is the facts themselves and the manner in which they are presented that is of prime importance. Any course in science that stops short of requiring original thinking by the student, thinking that is based upon facts that are leavened through and through with the results of personal observation and investigation must needs be comparatively barren of mental growth and vigor.

The logical result of such views is to regard the text-book in science as a reference book in simple compact form, furnishing what shall be needed to supplement the results of the student's own efforts in observation and thought,—a reference book differing not a whit in purpose from the other reference books found in any well appointed laboratory save in its larger use and *that it is the students' own*.

Happily the day was soon past when the science student of our secondary schools was looked upon as a discoverer, as one who by his unaided efforts was to re-establish the laws, principles and theories of the subject he pursued and all this as a result of his own investigations. The story of Agassiz, his student and the fish, was made to teach preposterous lessons. In most of the sciences the limits of original investigation are well defined, the need and use of text and reference books well established in supplementing laboratory work. In astronomy, however, oldest of the sciences, science of the material universe, the student is too often expected to know nothing save what his author tells him, to cultivate no mental powers in its study save the taxing of an already over-burdened memory; or, at most, his powers are taxed in making out what the author means in his text and through the exercise of the imagination in picturing what the author describes as existing.

In any attempt to apply the laboratory method to the teaching of astronomy there is the same necessity as in the other

sciences that no time be wasted upon comparatively unimportant phenomena; that observation shall be so carefully directed as to readily acquire the desired facts; and that these results shall be so related as to make generalization possible. That there are difficulties in the way is true, but they may largely be included under these heads: (1) A failure on the part of many teachers to appreciate the fact that although many of the phenomena of astronomical science require apparatus too expensive and too complicated to be available, many of the conclusions are reached through reasoning too abstract to be within the comprehension of the students to be instructed, there still is wide range for observation and inference fully within the comprehension of pupils of High School grade. (2) The text-books in astronomy with but an exception or two not only tell all the facts, those that the student can easily acquire for himself under direction as well as those beyond the range of his ability and opportunity, but, withal, their pages are crowded with ready-made inferences from these facts, making it wholly unnecessary for the pupil to do any thinking himself beyond that involved in language interpretation. He may study astronomy and complete his course with scarcely more of relation of his work to the phenomena about him than exists between the bookkeeping of the High School and the actual business conditions it is supposed to exhibit. Science teaching in any grade of school work should surely not make memory and imagination a first consideration—observation and thinking a secondary matter.

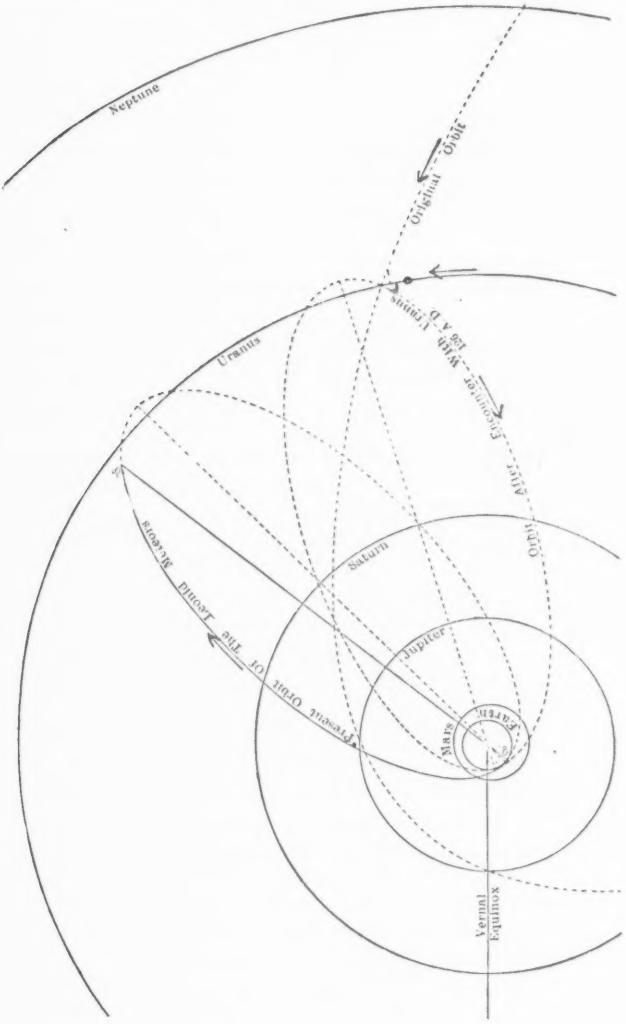
When teachers of astronomy shall be content no longer to instruct in this science upon a basis so radically different from that of the generally recognized laboratory sciences, and shall demand texts for laboratory reference books that are filled with facts clearly and logically arranged and having terse statements of the theories advanced therefrom, together with such descriptions and explanations as are beyond the ability of the average student for whom they are written, but which at the same time free of all such matter as may properly be required of students as the result of their own observation and thinking; when teachers shall demand that guides and manuals for the study of astronomy shall be furnished even as in physics and in chemistry, to the end that like principles of instruction and of laboratory procedure may be applied to all alike, then and not till then will publishers come to the relief of such teachers as already seek to secure in the teaching of astronomy in secondary schools the fullness of its possibilities for mental development, even as with other sciences, in addition to its value otherwise so fully recognized.

THE LEONID SHOWER OF METEORS IN 1899.

W. W. PAYNE.

As the time approaches, it may be well to call the attention of our readers once more to the expected display of the Leonid meteors which will occur on the 14th of the present month. Very much was said in our last number about the different prominent features of this great stream, and it seems almost unnecessary to refer again, so soon, to the same matter, which must be pretty clearly, already, in the minds of many who read these pages. But from the letters received recently and the questions asked in them, it seems best, at the risk of some repetition, to state again some of the leading facts pertaining to the Leonids that the same may be within the reach of some who may not have the opportunity of gaining them from other sources.

1. We take the following useful diagram from Mr. W. F. Denning's pamphlet, concerning this meteoric stream, published about one year ago, for the purpose of showing the path of the Leonid stream through the solar system, and to indicate the direction of motion of the swarm as it makes its long journey around the Sun once in about 33 years. It will be observed that the Leonid stream is moving in one direction in its path, while the Earth is moving in the opposite way in its orbit. If a watch is thought of as at the center of the system, with its face up, astronomers would say the Leonids move watch-wise and that the Earth's motion is counter watch-wise, meaning by this that the Leonids move with the hands of a watch while the motion of the Earth and the planets is in the opposite direction. At the point of intersection of the two orbits, it is then apparent that the Earth and the Leonids are moving in opposite directions, and that the apparent motion of the meteors in the sky is nearly the sum of the real motions of the two bodies. Hence the Leonids are swift, in relative velocity; they are green and bluish in color making vivid and persistent trains. These facts will help inexperienced observers to recognize the Leonids as soon as seen after a little practice. In the cut the line marked the vernal equinox will help the reader to find the position of the Earth as it approaches the path of the Leonids Nov. 14. On the 22d day of September the Earth passed the vernal equinox and from that to the 14th of this month it will have moved eastward through about one-sixth of its entire annual



b

path, bringing it to the intersection of the two orbits as spoken of above. The distance that the Earth traverses in passing through the stream is not definitely known, but it is consider-

able, for the displays that have occurred at past returns have continued for several hours. This fact does not measure a diameter of a cross-section of the stream, because undoubtedly the Earth goes obliquely through the stream making the time of the display longer than it would be if the motion were directly through it from side to side. It is also probable that the line of the Earth's motion is not central through the stream, but either above or below the middle line; that would vary the time of display. We have no certain knowledge of either the length of the dense part of the stream in its orbit, or of its diameter as given by a cross-section measure. The computations which can be used to obtain such data must be derived from the observations of individual meteors, and motions of these are subject to so many uncertainties and possible errors that results have so far proved not satisfactory in giving definite details.

2. The next point of general interest for all who may wish to watch the coming display, will be that a careful naked eye study of the constellations in every direction from Leo should be made beforehand. The map which was sent to all our readers last month places Leo near the center. The radiant point of the Leonids is within the "Sickle" of the constellation, and it is necessary that those who wish to do careful and good work in charting the paths of the meteors that they should know the stars near which the meteors may move so as to draw them quickly and accurately. In order to do this if the observer must stop to identify stars in sky as related to those in the chart much valuable time will be lost, and few trails will be secured, when many more might be secured if the observer were a little better prepared for his work beforehand as al eady indicated. This kind of work may be well done by astronomy classes in colleges and secondary schools and it is to be hoped that it will be tried all over the United States. There are indications already of some interest in the schools in view of the number of charts that have been asked for. We have distributed about 2009 copies of the chart, and it is evident that if half of them are used valuable results ought to follow.

3. It is important to know what can be said about the time and conditions of the shower for this month. In the pamphlet by Mr. Denning, before referred to, the following paragraph occurs which is to the point:

"Both favorable and unfavorable conditions will influence the character of the return shower in Nov. 1899. The meteors ought to form a splendidly abundant shower in England, for the cen-

tral and densest group is likely to encounter the Earth on Nov. 14 at 15^h, (one o'clock on the morning of the 15th, civil time) when the radiant will be fairly high, as at the time of maximum in 1866. Most unfortunately, however, the Moon will be nearly full and visible during the whole night. But if the sky is clear, it is certain that a large number of meteors will be observed. The moonlight will certainly obliterate many of the fainter objects and rob the brighter ones of much of their brilliant appearance, which is only fully realized when a dark sky affords its useful contrast. The appearance of a fine meteor is not startling so much on account of its size or suddenness as for the instantaneous manner in which it lights up the sky previously involved in darkness. With the rays of a nearly full Moon illuminating the prospect on Nov. 14, 1899, the flashing of large Leonids will quite lose its effect, and indeed, the whole display must suffer serious detraction. From the same cause the streaks left by the meteors will appear faint, and in many cases will escape detection altogether.

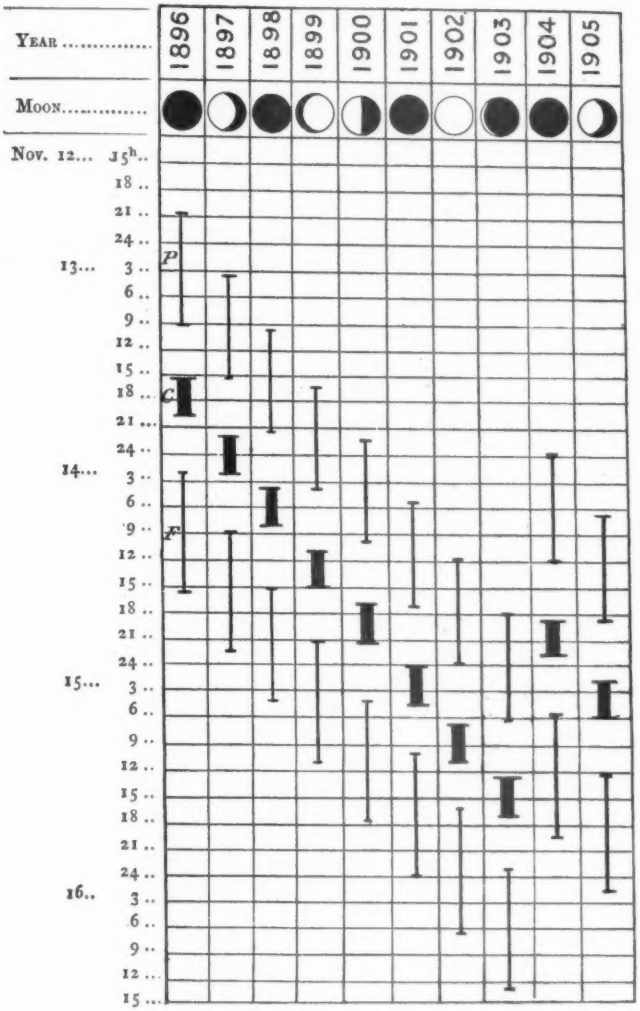
There will also be greater difficulty in accurately marking down the tracks of the individual meteors, as only tolerably bright stars will be visible. But in spite of all the drawbacks the shower should be attentively watched and its strength determined as carefully as the conditions allow. It is probable that it will fully repay every effort made to witness it."

In answer to several queries by persons interested in photography, as to what may be done by the aid of the camera during the Leonid shower, we would say, that some suggestions are offered under the head of general notes in this number, to those familiar with photographic work.

From what has already been said, it can be easily inferred that there must be elements of uncertainty in predicting the character of the displays as they return from year to year.

The stream is not equally dense everywhere probably; it stretches over a long space in its orbit; it must be somewhat disturbed by the attraction of planets when they are near, and it moves with varying velocity in different parts of its orbit. We can not know how the varying conditions will affect the values, as before noted, concerning the stream as it grazes Earth's atmosphere at the place of intersection of the two orbits and so predictions as to time and other characteristics will be, in some degree uncertain; yet Mr. Denning has prepared another interesting chart which is given herewith referring to the time of the display, in hours, on the 12th to 16th of November, for the years between

1896 and 1905. These data are given in Greewich Time; if one should wish to adapt the predictions to other places on the



Earth's surface, it will only be necessary to subtract the difference in time for any place in west longitude for places west, and add like amount to Greenwich Time for places east.

It has been thought by some from observations made in 1866

and 1867, that the stream consisted of three parts, the central and densest part, flanked on either side by streams of minor strength but wider in extent. These divisions are provided for in the cut and marked by the letters C, P and F. The meaning of the heavy and the light lines will be readily understood. At the top of the cut is given the years and the phases of the Moon during the times of display for each, the light part of the circles indicating the age of the Moon at the respective times.

We want also to repeat a part of what Mr. Denning has said about the observations that are desired.

"As to the observations necessary to be made, they may be described as manifold. It is not sufficient to stand and merely count the numbers visible at certain intervals, and jot down a few notes of the brighter objects. The phenomenon requires critical watching with regard to certain important features, and among these the following may be instanced:—

1. The exact time of maximum abundance.
2. The number of meteors visible per minute at maximum.
3. The position of the centre of radiation.
4. The diameter of the area of the radiant, if diffuse.
5. The duration of the shower's chief activity.
6. The whole duration of its visibility (from about Nov. 7 to 20.
7. The relative magnitudes of the meteors.
8. The durations of their visible flights.
9. The colors of the meteors and of their streaks.
10. The durations of the streaks and extent and direction of their drift. In the case of very bright streaks enduring a long time a series of positions for the central part should be taken say at intervals of 2 or 3 minutes.
11. The apparent paths of the brighter meteors. Many of these will be sure to be seen at several stations, and if properly recorded the data will enable their real paths to be derived.
12. The places of apparition of stationary meteors.
13. The number of meteors proceeding from other showers. These will probably not amount to more than 10 or 12 per hour, and need not be considered during a really brilliant return of the Leonids. During a feeble display, however, meteors diverging from the minor systems should be carefully separated from the Leonids or the real strength of the latter will be exaggerated.
14. The shape of the nuclei and their apparent diameters in the case of bolides.

15. Instances of curved paths, broken streaks, and other visible peculiarities.

After the disruption of large meteors the observer should listen for some minutes with the idea of noticing any audible detonation should it occur.

Of course more than two observers must be employed to thoroughly record the characteristics of a meteoric display. One should count the numbers visible during, say, every successive period of 5 minutes, and record the totals, so that the rate of increase, time of max., rate of decrease, and the duration of great activity may be severally determined. Another will register the paths of individual meteors, determine the place of the radiant at, say, half-hourly intervals, while a third will derive the relative magnitudes by watching one particular quarter of the heavens and recording the various magnitudes of all the meteors which appear there. By separating the materials collected in this way into half-hourly intervals, it might be seen whether any variation occurred during the rise, height, and fall of the display, or whether the altitude of the radiant exercised any influence upon the apparent brilliancy of the meteors.

One observer, in relying upon his own exertions, will perhaps do best by counting the meteors during every alternate five minutes, and recording paths and other details in the intervals. Should meteors be too numerous for exact enumeration, the number ought to be carefully estimated. Or by watching a very contracted region of the sky (which might be done by standing far back from an open window, or by looking through an empty telescope-tube, or by some other device which the observer might readily arrange for himself), the number of meteors appearing in the field might be counted; and the diameter and altitude of the space under view being known, as well as the average length of the paths, a computation might easily be made as to the number of meteors which appeared in the whole sky.

The greater the number of observers the larger the total of meteors that will be seen. Experiments have been occasionally made to ascertain the relative numbers; thus during the Leonid display of 1865 Professor Newton obtained the following figures* from a simultaneous watch of different parts of the heavens by 12 observers:—

* Dr. Kleiber gave a similar table in Ast. Nach. 2621.

No. of observers.	No. of meteors seen.	No. of observers.	No. of meteors seen.	No. of observers.	No. of meteors seen.
1.....	325	5.....	1106	9.....	1399
2.....	633	6.....	1200	10.....	1451
3.....	836	7.....	1282	11.....	1509
4.....	1000	8.....	1348	12.....	1560

Professor Newton was led to assume that the total number visible in the whole firmament was 2,400, so that one observer may expect to see more than one-eight of the aggregate, while six observers will record one-half.

REPORT ON PROGRESS IN NON-EUCLIDEAN GEOMETRY.

GEORGE BRUCE HALSTED.

From *Science*, No. 251.

It marks an epoch in the history of mathematics that at a meeting of a great association for the advancement of science there should be presented by invitation a report on non-Euclidean geometry.

Its two creators, Lobachévski, who misnamed it imaginary geometry, and Bolyai János, under the nobler name science absolute of space, failed utterly while they lived, to win any appreciative attention for what is today justly honored as one of the profoundest advances of all time. The only recognition, the only praise of the achievement of Lobachévski ever printed in his lifetime was by Bolyai Farkas, the father of his brilliant young rival, and appeared in a little book with no author's name on the title page, and which we have no evidence that Lobachévski ever saw, a little book so rare that my copy is probably the only one on the western continent.

When after more than forty years they were rescued from oblivion by Baltzer and Hoüel in 1866, still envious time gave them back only with an aspertion against the genuineness of their originality. A cruel legend tarnished still their fame so long delayed, so splendidly deserved.

Even when their creation had reached the high dignity of being made the subject of courses of lectures for consecutive semesters at the University of Göttingen, yet on page 175 of the second impression of these lectures, 1893, we still find Felix Klein saying, "Kein Zweifel bestehen kann, dass Lobatscheffsky sowohl wei Bolyai die Fragestellung ihrer Untersuchungen der Gaussichen Anregung verdanken."

It is a privilege to begin my report by announcing the rigorous

demonstration that this ungenerous legend is untrue. This point need not further delay us, since it has been treated by me at length in *Science*, N. S. Vol. IX, No. 232, pages 813-817, June 9, 1899.

What a contrast to the pathetic neglect of its creators, Lobachéviski dying blind, unrecognized, without a single follower, Bolyai János dying of disgust with himself and the world, lies in the fact that less than a year ago our American magazine, the *Monist*, secured from the famous Poincaré, at great cost, a brilliant contribution to this now universally interesting subject, which I had the honor, through my friend T. J. McCormack, of reading in the original French manuscript.

This extraordinary paper, published only in English translation, appears in the *Monist*, Vol. 9, No. 1, Oct., 1898, pages 1-43. In the first section of his greatest work, Lobachévski says: "*Juxtaposition* (contact) is the distinctive characteristic of solids, and they owe to it the name *geometric solids*, when we retain this attribute, taking into consideration no others whether essential or accidental.

"Besides bodies, for example, also time, force, velocity are the object of our judgment; but the idea contained in the word juxtaposition does not apply thereto. In our mind we attribute it only to solids, in speaking of their composition or dissection into parts.

"This simple idea, which we have received directly in nature through the senses, comes from no other and consequently is subject to no further explanation. Two solids A and B, touching one another, form a single geometric solid C, in which each of the component parts A, B appears separate without being lost in the whole C. Inversely, every solid C is divided into two parts A and B by any *section* S.

"By the word section we understand here no new attribute of the solid, but again a juxtaposition, expressing thus the partition of the solid into two juxtaposed parts.

"In this way we can represent to ourselves all solids in nature as parts of a single whole solid which we call space."

Poincaré starts off somewhat differently. He says: "We at once perceive that our sensations vary, that our impressions are subject to change. The laws of these variations were the cause of our creating geometry and the notion of geometrical space.

"Among the changes which our impressions undergo, we distinguish two classes:

"(1) The first are independent of our will and not accompanied by muscular sensations. These are *external changes* so-called.

"(2) The others are voluntary and accompanied by muscular sensations. We may call these *internal changes.*

"We observe next that in certain cases when an external change has modified our impressions, we can, by voluntarily provoking an internal change, re establish our primitive impressions. The external change, accordingly, can be *corrected* by an internal change. External changes may consequently be subdivided into the two following classes:

"1. Changes which are susceptible of being corrected by an internal change. These are *displacements.*

"2. Changes which are not so susceptible. These are *alterations.* An immovable being would be incapable of making this distinction. *Such a being, therefore, could never create geometry,* even if his sensations were variable, and even if the objects surrounding him were movable."

How like what Lobachévski said more than sixty years before: "We cognize directly in nature only motion, without which the impressions our senses receive are not possible. Consequently, all remaining ideas, for example, geometric, are created artificially by our mind, since they are taken from the properties of motion; and therefore space in itself for itself alone, does not exist for us."

Poincaré continues: "*The aggregate of displacements is a group.*" At once rise before us the great names Riemann, Helmholtz, Sophus Lie. In fact Poincaré's next section is merely a restatement of part of Riemann's marvellous address, published 1867, on the hypotheses at the basis of geometry.

Again, though the work of Helmholtz did not contain the group idea, yet it had put the problem of non-Euclidean geometry into the very form for the instrument of Sophus Lie, who calls it the Riemann-Helmholtz Space-problem.

To the genius of Helmholtz is due the conception of studying the essential characteristics of a space by a consideration of the movements possible therein.

Felix Klein it was who first called the attention of Lie to this work of Helmholtz, before then unknown to Lie, and pointed out its connection with Lie's Theory of Transformation groups, inciting him to a group-theory investigation of the problem. In 1886 Lie gave briefly his weightiest results in a note: "Bemerkungen zu v. Helmholtz' Arbeit über die Thatsachen, die der Geometrie zu Grunde liegen," in the Berichte of the Saxon Academy, where, in 1890, he gave his completed work in two papers, 'Ueber die Grundlagen der Geometrie' (pp. 284-321, 355-418).

The whole investigation published in Volume III of his 'Theorie der Transformationsgruppen,' 1893, was in 1897 awarded the first Lobachévski prize. Felix Klein declared that it excels all comparable works so absolutely that a doubt about the award could scarcely be possible. Lie gives two solutions of the problem. In the first he investigates in space a group possessing free mobility in the infinitesimal, in the sense, that if a point and any line-element through it be fixed, continuous motion shall still be possible; but if besides any surface element through the point and line-element be fixed, then shall no continuous motion be possible. The groups in tri-dimensional space possessing in a real point of general position this free mobility, Lie finds to be precisely those characteristic of the Euclidean and two non-Euclidean geometries. Strangely enough, for the seemingly analogous and simpler case of the plane or two-dimensional space these are not the only groups. There are others where the paths of the infinitesimal transformations are spirals. Without the group idea, Helmholtz had reached this reality. and as a consequence concluded that also to characterize our tri-dimensional spaces a new condition, a new axiom, was needed, that of *mondromy*. It is one of the most brilliant results of Lie's second solution of the space problem, that starting from transformation-equations with three of Helmholtz's four assumptions, he proves that the fourth, the famous 'Monodromie des Raumes,' is, in space of three dimensions, wholly superfluous. What a demonstration of the tremendous power of Lie's group theory! Lie's method, in general, as it appears in the Berichte, is the following:

Consider a tri-dimensional space in which a point is defined by three quantities x, y, z.

A movement is defined by three equations: $x_1 = f(x, y, z)$; $y_1 = \varphi(x, y, z)$; $z_1 = \psi(x, y, z)$.

By this transformation an assemblage, A, of points (x, y, z) becomes an assemblage, A', of points, (x_1, y_1, z_1).

This represents a movement which changes A to A'. Now make, in regard to the space to be studied, the following assumptions:

(B) In reference to any pair of points which are moved, there is *something* which is left unchanged by the motion. That is, after an assemblage of points, A, has been turned by a single motion into an assemblage of points, A', there is a certain function, Ω, of the coördinates of any pair of the old points (x_1, y_1, z_1), (x_2, y_2, z_2) which equals that same function, Ω, of the

corresponding new coördinates (x_1', y_1', z_1'), (x_2', y_2', z_2'); that is

$\Omega(x_1', y_1', z_1', x_2', y_2', z_2') = \Omega(x_1, y_1, z_1, x_2, y_2, z_2)$. This *something* corresponds to the generalized idea of distance interpreted as independent of measurement by superposition of an unchanging sect as unit for length. Moreover assume:

(C) If one point of the assemblage is fixed, every other point of this assemblage, *without any exception*, describes a surface (a two-dimensional aggregate). When two points are fixed, a point in general (exceptions being possible) describes a curve (a one-dimensional aggregate). Finally, if three points are fixed, all are fixed (exceptions being possible). Then Lie proves exhaustively that the group consists either of all motions of Euclidean space or of all motions of non-Euclidean space.

The result is a remarkable one, demonstrating that the group of Euclidean motions and the group of non-Euclidean motions are, in tri-dimensional space, the only groups in which exists in the strict sense of the word free mobility. Thus free motion in the strict meaning of the word can happen in three and only three spaces, namely, the traditional or Euclidean space, and the spaces in which the group of movements possible is the projective group transforming into itself one or the other of the surfaces of the second degree $x^2 + y^2 + z^2 \pm 1 = 0$.

To the fundamental assumption which completely characterizes these three groups, Lie gives also this form:

"If any real point, y_1^0, y_2^0, y_3^0 of general position is fixed, then all real points x_1, x_2, x_3, into which may still shift another real point x_1^0, x_2^0, x_3^0, satisfy a real equation of the form:

"$W(y_1^0, y_2^0, y_3^0; x_1^0, x_2^0, x_3^0; x_1, x_2, x_3) = 0$, which is not fulfilled for $x_1 = y_1^0$, $x_2 = y_2^0$, $x_3 = y_3^0$, and which represents a real surface passing through the point x_1^0, x_2^0, x_3^0.

"About the point y_1^0, y_2^0, y_3^0, may be so demarcated a triply extended region, that on fixing the point y_1^0, y_2^0, y_3^0, every other real point, x_1^0, x_2^0, x_3^0, of the region can yet shift continuously into every other real point of the region, which satisfies the equa- $W = 0$ and which is joined to the point x_1^0, x_2^0, x_3^0, by an irreducible continuous series of points."

It is a satisfaction to the world of science that Lie's vast achievements were recognized while he lived. Poincaré accepts and expounds his doctrine, saying in the article already mentioned: "The axioms are not analytical judgments *a priori*; they are conventions. * * * Thus our experiences would be equally compatible with the geometry of Euclid and with a ge-

ometry of Lobachévski which supposed the curvature of space to be very small. We choose the geometry of Euclid because it is the simplest.

"If our experiences should be considerably different, the geometry of Euclid would no longer suffice to represent them conveniently, and we should choose a different geometry."

When on November 3, 1897, the great Lobachévski prize was awarded to Lie, three other works were given honorable mention. The first of these is a thesis on non-Euclidean geometry by M. L. Gérard, of Lyons. Lovers of the non-Euclidean geometry are naturally purists in geometry, and keenly appreciate Euclid's using solely such figures as he has rigorously constructed. They understand that problems of construction play an essential part in a scientific system of geometry. Far from being solely, as our popular text-books suppose, practical operations, available for the training of learners, they have in reality, as Helmholtz declares, the force of existential propositions. Therefore is evident the high import of Gérard's work to establish the fundamental propositions of non-Euclidean geometry without hypothetical constructions other than the two assumed by Euclid: 1. Through any two points a straight line can be drawn; 2. A circle may be described from any given point as a center with any given sect as radius. Gérard adds explicitly the two assumptions: 3. A straight line which intersects the perimeter of a polygon in a point other than one of its vertices intersects it again; 4. Two straights, or two circles, or a straight and a circle, intersect if there are points of one on both sides of the other.

Upon these four hypotheses, perfecting a brilliant idea of Battaglini (1867). Gérard establishes the relations between the elements of a triangle.

Lobachévski never explicitly treats the old problems changed by transference into the new geometric world, such as "Through a given point to draw a parallel to a given straight"; nor yet the seemingly impossible problems now in it capable of geometric solution, such as "To draw to one side of an acute angle the perpendicular parallel to the other side"; "To square the circle."

These would be sought in vain in the two quarto volumes of Lobachévski's collected works. Bolyai János, in his all too brief two dozen pages, gives solutions of them startling in their elegance.

But in establishing his theory, he uses, for the sake of conciseness, the principle of continuity even more freely than does Lobachévski.

Gérard, in the second part of his memoir, gives the elements of non-Euclidean analytic geometry, and in the third part, a strict treatment of equivalence.

Even Euclid, in proving his I., 35, "Parallelograms on the same base, and between the same parallels, are equal to one another," does not show that the parallelograms can be divided into pairs of pieces admitting of superposition and coincidence. He uses rather the assumption explicitly set forth by Lobachévski, "Two surfaces are equal when they are sums or differences of congruent pieces." But Creswell in his *Treatise of Geometry*, showed how to cut the parallelograms into parts congruent in pairs. The same can be done for Euclid I., 43, "The complements of the parallelograms, which are about the diagonal of any parallelogram are equal." Hence, we may use the definition: Magnitudes are equivalent, which can be cut into parts congruent in pairs. This method I applied to ordinary Euclidean geometry in my Elementary Synthetic Geometry before the appearance of Gérard's work, where it is extended to the non-Euclidean.

Regarding the first assured construction of Euclid and Gérard: "A straight line can be drawn through any two points," W. Burnside has given us a charming little paper in the *Proceedings of the London Mathematical Society*, Vol. XXIX., pp. 125–132 (Dec. 9, 1897), entitled 'The Construction of the Straight Line Joining Two Given Points.' Euclid's postulate implies the use of a ruler or straight-edge of any required finite length. The postulate is clearly not intended to apply to the case in which the distance between two points is infinite. In fact, Euclid I., 31, gives a compass and ruler construction for the line when one of the points can be reached while the other cannot. The other exceptional case when neither point can be reached, *i. e.*, when two given points are the points at infinity on two non-parallel lines, is not dealt with by Euclid.

In elliptic space any one point can be reached from any other by a finite number of finite operations. The line joining two given points can therefore be always constructed with the ruler alone. In hyperbolic space, if we deal with projective geometry, we must assume that *every* two straight lines in a plane determine a point. When the two straight lines are non-intersectors, the point can neither be a finite point nor a point at infinity. Such a point is termed an 'ideal' point. The problem of constructing the straight line joining two given points involves therefore three further caseses; namely, (IV) that in which one of the points is a

finite point and the other an ideal point; (V) that in which one is a point at infinity and the other an ideal point; (VI) that in which both points are ideal points.

It is a pleasure to signal the appearance, within the past year, of the scond volume of the exceedingly valuable work of Dr. Wilhelm Killing, 'Einführung in die Grundlagen der Geometrie,' (Paderborn, 1898).

With Killing's name will be associated the tremendous difference living geometers find between the properties of a finite region of space, and the laws which pertain to space as a whole. Of the word *direction* he says "it can only be given a meaning when the whole theory of parallels is already presupposed.

The pseudo-proof of the parallel postulate still given in current text-books, for example, by G. C. Edwards in 1895, Killing calls the Thibaut proof, saying that it has especial interest because its originator, who was professor of mathematics at Göttingen with Gauss, published the attempt at a time, 1818, when Gauss had already called attention to the failure of attempts to prove this postulate, and declared that we had not progressed beyond where Euclid was 2000 years before.

But Killing is here in error when he supposes Thibaut the originator of this popular pseudo-proof. It was given in 1813 by Playfair in his edition of Euclid, in a Note to I., 29. It was very elegantly shown to be a fallacy by Colonel T. Perronet Thompson, of Queen's College, Cambridge, in a remarkable book called 'Geometry without Axioms,' of which the third edition is dated 1830, a book seemingly unknown in Germany, since Engel and Staeckel copy from Riccardi the title (with the mistake 'first books' for 'first book') under the date 1833, which is the date of the fourth edition.

Killing has won an important place by investigating the question, what varieties of connection of space are compatible with the different elemental arcs of constant curvature. Riemann, Helmholtz and Lie consider only a region of space, and give analytic expressions for the vicinity of a point. If this region be extended, the question is, what kind of connection of space can result.

Killing shows there are different possibilities, really a series of topologically different forms of space with Euclidean, Lobachévskian, Riemannian geometry in the bounded, simply connected region.

The germinal idea is due to Clifford, who, in an unprinted address before the Bradford meeting of the British Association

(1873), 'On a surface of zero curvature and finite extent,' and also by a remark in his paper 'Preliminary sketch of biquaternions,' called attention to a recurrent surface in single elliptic space, which has everywhere zero for measure of curvature, yet is nevertheless of finite area.

Similarly complete universal spaces are found of zero or negative measure of curvature, which nevertheless are only of finite extent. Since there is no way of proving that the whole of our actual space can be moved in itself in ∞^6 ways, it may possibly be, after all, one of these new Clifford spaces. Free mobility of bodies may only exist while they do not surpass a certain size.

Killing devotes an interesting section, over seven pages, to Legendre's definition of the straight line as the shortest distance between two points. He emphasizes three principal reasons why this is inadmissible. These are (*a*) since the possibility of measurement for all lines is presumed beforehand, which is not allowable; (*b*) since before the execution of the measurement there must be a measuring standard, but this is first given by the straight line; (*c*) since the existence of a minimum is not evident, on the contrary can be demanded only as an assumption.

The first objection was always conclusive, yet it strengthens every day, for our new mathematics knows of lines, real boundaries between two parts of the plane, to which the idea of length is inapplicable.

(To be Continued.)

SPECTROSCOPIC NOTES.

The brilliant inauguration of the enlarged Astrophysical Observatory at Potsdam, Aug. 26, in the presence of the German Emperor, is described in *Sirius* for October. The Emperor was received at the entrance by Professor Vogel, the director of the Observatory and two cabinet ministers, von Bosse and von Thielen. Escorted by them the Emperor came into the great dome, richly decorated for the occasion, where about one hundred guests were assembled. Professor Vogel in a long address gave an account of the history of the Observatory; American admirers of the work of this Observatory will be glad to notice his statement that its foundation twenty-five years ago was largely due to the special interest of the crown prince (afterward Emperor) Frederick, so highly regarded in this country for his enlightened and progressive ideas. Professor Scheiner followed, enumerating the plans and the advantages of the new structure with its great telescope (33-inch photographic). The Emperor then announced the distinctions conferred on the occasion; and in the informal exercises which followed is reported to have conversed cordially with those who were present.

The organization of the Astronomical and Astrophysical Society of America

will provide for the continuance of the recent annual conferences of astronomers and astrophysicists. Meetings such as these are needed for the double purpose of fixing for investigators in spectroscopy, as well as in the old astronomy, a time and place for meeting and discussion, and of offering students and friends of the subject an opportunity of acquiring accurate information at first hand. Until recently Section A (Mathematics and Astronomy) of the American Association for the advancement of Science has been about the only appointed place where spectroscopists might be expected to meet; and who has attended these sessions without feeling that something additional is needed? The new body will offer a great advantage in the fact of meeting each year at some place where an extensive astronomical outfit may be inspected, and probably at least half the time where the spectroscopic equipment forms an important part. The problem, so difficult in spectroscopy as in any other branch of science in our country of magnificent distances, of getting together men so widely separated, the new society will probably do much to solve.

In *Astronomische Nachrichten* 3593 Professor Scheiner of Potsdam contends that Professor Keeler's photographic observations, showing variations in the character of the light in different parts of the Orion nebula, are not conclusive. Professor Keeler, using a reflector, exposed first an ordinary plate, securing a photograph of the nebula produced chiefly by *Hγ* (violet) light; then an orthochromatic plate with a yellow screen, securing a photograph of the nebula produced chiefly by the light of the nebular lines in the green. When the exposures were so timed that the central part of the nebula was equally intense on the two plates, then the fainter outlying parts were very unequal, being weaker on the orthochromatic plate than on the ordinary plate; indicating that in these fainter portions of the nebula a greater proportion of the light is violet than in the central portions. Professor Scheiner claims that this result is illusory. In his experience with photographic plates he has long been accustomed to the uncertain behavior of plates in the matter of responding to the action of faint light. In particular he gives his measurements for an instance where with light of uniform composition throughout the result is strongly irregular, though in the opposite way from Professor Keeler's results for the nebula. He concludes that there is nothing in Professor Keeler's results to establish any lack of homogeneity in the light of the nebula.

Professor Scheiner further contends that Professor Runge in measuring the Purkinje phenomenon has come to results much too small by using surfaces instead of lines.

Professor Campbell, observing with the Mills spectroscope of the Lick Observatory, has found variations of its motion in the line of sight which indicate that Polaris is a spectroscopic triple star. The velocity varies between limits of 8 kilometers (5 mi.) per second of approach and 14 km. (9 mi.) per sec. of approach, in a period of four days. Some observations taken in 1896 give a velocity of 20 km. (12 mi.) per sec. of approach. Using an analogy from the solar system, a correct idea of the explanation of these results may be formed by imagining the Sun (dark), with the center of gravity of the Earth (dark) and Moon revolving around it at a great distance and in a period not yet known but probably some years; the Moon (bright, the Polaris which we see) distant about 100,000 miles from the centre of gravity of the Earth and Moon, revolving around this center of gravity in four days, with a velocity of two miles per second.

VARIABLE STARS.

J. A. PARKHURST.

Minima of the Variable Stars of the Algol Type.

(Given to the nearest hour in Greenwich Time.)

1899.

U CEPHEI.

	d	h
Dec.	3	11
	5	23
	8	11
	10	23
	13	11
	15	22
	18	10
	20	22
	23	10
	25	22
	28	10
	30	21

W DELPHINI.

	d	h
Dec.	22	7

ALGOL.

	d	h
Dec.	3	19
	6	15
	9	12
	12	9
	15	6
	23	20
	26	17
	29	14
	32	11

λ TAURI.

	d	h
Dec.	3	8
	7	7
	11	6
	15	5

S CANCRI.

	d	h
Dec.	1	9
	10	21
	20	9
	29	20

U CORONAE.

	d	h
Dec.	1	16
	8	14
	25	20

R CANIS MAJ.

Every 8th min.
P = 1d 3h.3

	d	h
Dec.	6	17
	15	19
	24	21

S VELORUM.

	d	h
Dec.	2	12
	8	10
	14	9
	20	7
	26	6

DM + 45°3062

	d	h
Dec.	3	19
	8	9
	12	23
	17	13
	22	2
	26	16
	31	6

NOTES.

THE LONG PERIOD EPHEMERIS for 1899 has not appeared. That in the *Vierteljahrsschrift* or the *Companion to the Observatory* is generally published in November or December.

CORRECTION TO CHART FOR CERASKI'S NEW ALGOL-TYPE VARIABLE in the July-Aug. number, page 380. In all the impressions I have seen there is a spurious star 1-16 of an inch to the left of the letter "a" in the larger scale chart.

SAWYER'S ALGOL-TYPE VARIABLE, DM. + 12°3557. This star will be too far west for good observations in December. No observations have been published since the announcement by the discoverer in *Astronomical Journal*, No. 447 (Oct. 1898). The epoch number will be 500 Dec. 2.2, and as the period was only given to the nearest minute the ephemeris may be in error five or six hours, and therefore quite misleading. The chart and elements were given in Vol. VI, page 581, of this journal.

DM. + 45°3062. The above ephemeris is that given by Professor E. C. Pickering in Harvard College Observatory Circular No. 44. The elements there given, deduced from 20 minima between 1887 Sept. 23 and 1899 June 8, are

1889 Dec. 6, 14h 22m Gr. T. + 4d 13h 45m 2s E.

which expressed in Julian days and fractions is

2411343d.605 + 4d.57294 E.

With these elements, the minimum of 1899 May 7.454, which was assumed as

the zero epoch in the July number, page 379; becomes No. 752. The agreement at this time is quite exact, the computed minimum according to Pickering's elements being May 7.456. The difference then is entirely in the length of period assigned, that deduced by Professor Ceraski being $4^d\ 13^h\ 44^m$, or 1 minute shorter than Pickering's.

I have 45 observations of this star, covering 8 minima between 1899 June 26 and Sept. 12. Arranged in order of time interval from the ephemeris minima based on Ceraski's period, they give a correction of $+\ 29^m$ for the mean epoch, the minimum of Aug. 2. This minimum was due

By Ceraski's elements,	Aug. $2^d\ 7^h.8$
By Pickering's elements,	Aug. $2^d\ 8^h.2$
My observations give	Aug. $2^d\ 8^h.3$

thus tending to confirm Pickering's period.

The magnitudes on the scale which I have used are 8.7 at normal light, and 11.4 at minimum, an unusually large range for an Algol-type star.

The cause of the light variations of variables of this type is generally assigned to eclipses of a companion star, too close to the primary to be detected by visual or photographic means. This theory would seem to demand perfect symmetry in the two branches of the light curve, unless the orbit were quite eccentric. The dis symetry in the light curve of Algol has been urged by some as showing incompleteness in the theory, in spite of the confirmation afforded by spectroscopic results. With this state of affairs the discovery of every new Algol-type star is of great interest, as affording possible confirmation of the theory. Unfortunately this new star is so faint, even at normal light, that it is doubtful whether with present appliance its spectrum can be photographed with sufficient dispersion to detect a shift in the lines which might be caused by orbital motion. As bearing on this question we may quote the statement made in the *Astrophysical Journal*, Vol. X, page 100, in regard to photographs with the 40-inch Yerkes telescope, "With a slit-width of 0.15 mm. and a dispersion of three 60° prisms, the yellow and green regions of the spectrum of 280 *Schjellerup* (mag. 7.8) required an exposure of nine hours." This was a red IV-type star, but Mr. Ferdinand Ellerman, who made the above exposure, informed me that a I-type star of magnitude 8.7 would require nearly the same exposure time.

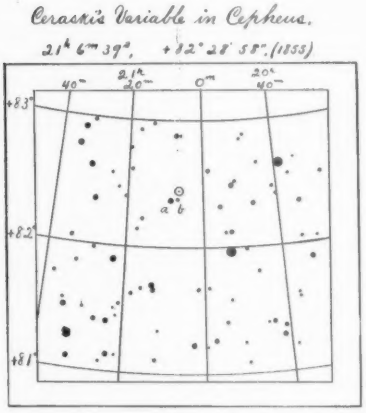
CERASKI'S VARIABLE IN CEPHEUS. In No. 3512 of the *Nachrichten*, Professor W. Ceraski announced the discovery of this variable from a study by his wife, Madam L. Ceraski, of photographs taken by his assistant, M. S. Blajko. The variation was confirmed by visual observations, the star being 10^m and fading 1898 July 13 (see Vol. VI, page 532, of this journal). I found a 12^m star near the place 1898 Sept. 6, and measured its place relative to the two neighboring DM. stars. This proved to be the variable, but at the time of measurement, Oct. 11, it was too faint to admit of accurate settings of the micrometer threads. The star faded slowly till it passed below the limit of the 6 2 inch reflector early in November. The place was examined about twice a month from that time on till the variable reappeared. On 1899 Aug. 30 it was not visible, the limit being $12^m.5$, but at the next observations, Sept. 26, it had risen to about 10^m, where it remained till the present time.

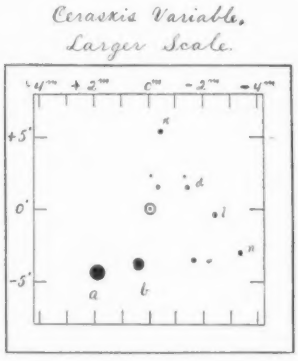
The place estimated by Professor Ceraski was

R. A. $21^h\ 6^m.9$, Decl. $+\ 82°\ 28'.0$, (1855).

the result of my measures this month, using as comparison stars a = DM. $+$ 82°636, and b = 82°635, is

R. A. 21^h 6^m 39^s Decl. $+82°$ 28′ 58″ (1855)
3 39 39 50 (1900)





The accompanying chart on the scale of the Durchmusterung gives the stars from 6^m to 10^m within about one degree of the variable, the larger scale chart gives the stars from $8^m.5$ to $12^m.5$ in a region 16′ square with a variable in the center. For the sake of clearness only part of the stars are lettered on the latter chart, the rest can be located by means of the following table:

COMPARISON STARS FOR CERASKI'S VARIABLE IN CEPHEUS.

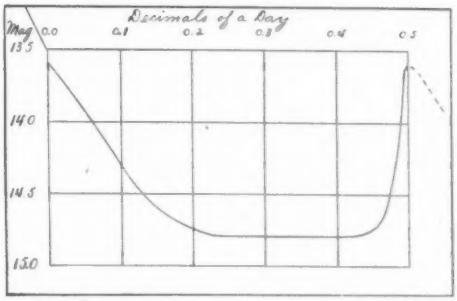
	Co-or. from V. R. A. ′	″	Decl. ′	Mag.		Co-or. from V. R. A. ′	″	Decl. ′	Mag.
n	−6 3	−199	−3.0	12	*k*	−0.8	− 26	+5 4	11.7
l	−4.6	−144	−0.3	12	*e*	−0.6	− 20	+1.5	12
m	−4 1	−130	−3 6	12.5	*g*	−0.2	− 7	+2 3	12.5
h	−3.1	− 97	−3 5	11.7	*b*	+0.8	+ 23	−3 9	9 3
d	−2.7	− 86	+1.5	12	*a*	+3.6	+110	−4.4	8.5
f	−2.5	− 81	+2.2	12.5					

THE PERIODS OF SOME OF THE VARIABLE STARS IN THE CLUSTER MESSIER 5. (As the cut showing the light curve of variable No. 33 was accidentally omitted from the last issue, page 436, the note is here repeated to accompany the cut, as the two are necessary for mutual explanation.)

A paper with the above title by Professor S. I. Bailey, of Arequipa, Peru, was read by Professor Barnard at the conference at the Yerkes Observatory, Sept. 8. Of the 85 variables in the cluster Professor Bailey communicated data in regard to about 40, which were so nearly alike in magnitude, range of variation, period, and form of light curve, as to suggest for this form the title of the "Cluster Type" of variables. These stars are all within 11′ of the center of the cluster, the brightest is $13^m.4$ at maximum and the faintest $14^m.9$ at minimum. Their range of variation is about one magnitude, the least being $0^m.7$ and the greatest $1^m.4$. The periods are included between $0^d.400$ and $0^d.699$, averaging $0^d.526$.

In regard to the form of light curve, Professor Bailey says that it is quite uniform for all these stars, but that no such similarity exists for the numerous vari-

Light Curve of Variable No. 33 in the Cluster Messier 5.



ables in the cluster ω Centauri. Details were given for four of the stars, the curve for one, No. 33, is reproduced here. The period is given as $0^d.500744$, and the range of variation from $13^m.6$ to $14^m.8$. As will be seen from the curve, the time of fall occupies 40% of the period, the normal light 50% and the rise 10%, the fall beginning again immediately after the maximum is reached.

An inspection of the curve at once suggests its resemblance to that of SS Cygni (and probably of U Geminorum), in fact, they are almost identical in proportions except that the rise is more rapid in case of SS. But even this lack of identity is fully supplied by Professor Bailey's report of his methods of observation, and by Professor Barnard's visual observations with the Yerkes 40-inch. The magnitudes used by Professor Bailey were all found from photographs taken with the 13-inch Boyden telescope with exposures of one or two hours. As pointed out by the author, such exposures, bearing so great a ratio to the whole period, will mask the variations to some extent and tend to "smooth out" the curve. For instance, an exposure of two hours, $0^d.8$, beginning at $0^d.42$ in the figure and ending at $0^d.50$, would give for the middle time, $0^d.46$, the integral of the light during that interval, or about $14^m.2$ or $14^m.3$, a value of more than $0^m.5$ too high; thus showing a rise even more gradual than in the figure. Professor Barnard found from visual observations that the rise took place in 15 or 20 minutes, or about 2% of the whole period. The above cause of difference between the visual and photographic results was pointed out by Professor Bailey in a paper read before the conference. With this correction the duration of normal light becomes 58% of the period, and if a slight correction is made for similar reasons to the beginning, the duration can be taken as approximately 60% of the period. For SS Cygni the rise occupies about 2% and the normal light averages 68% of the period, a resemblance sufficiently close to link together the "U Geminorum" and the "Cluster" types.

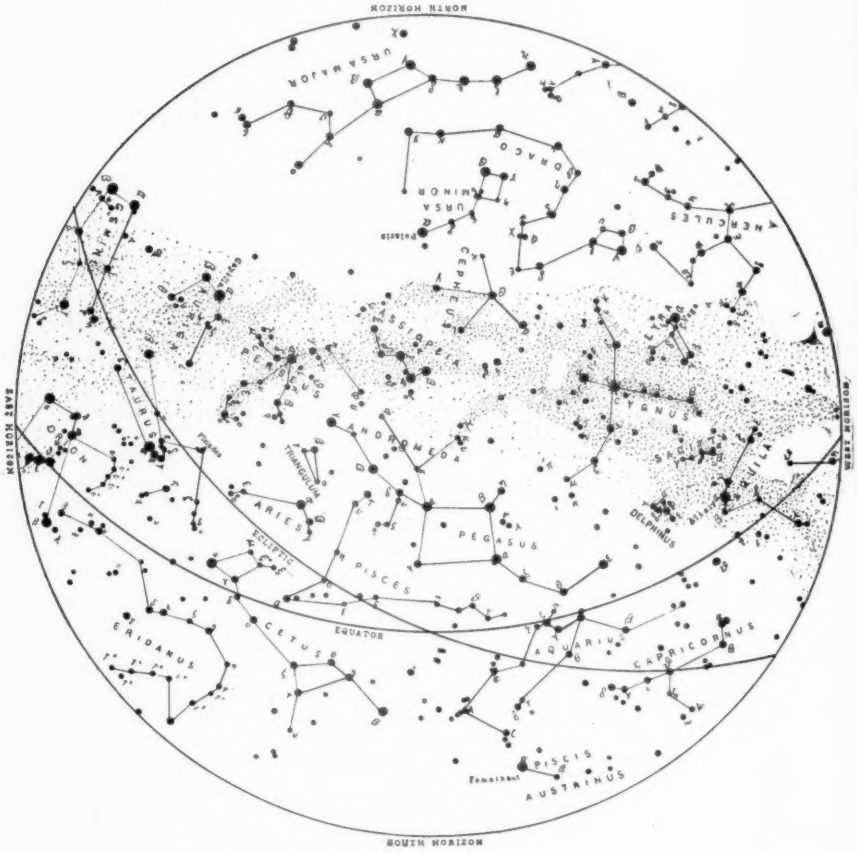
PLANET NOTES FOR NOVEMBER.

H. C. WILSON.

Mercury, Venus, Mars, Jupiter, Saturn and Uranus are all in that part of the zodiac which is hidden by the glare of the sun, as will appear from the following table:

POSITIONS OF THE PLANETS FOR NOVEMBER

	Nov. 1. R. A.		Nov. 1. Decl.		Nov. 30. R. A.		Nov. 30. Decl.	
	h	m	°	′	h	m	°	′
Sun	14	26	− 14	32	16	26	− 21	42
Mercury	15	38	− 21	31	17	18	− 23	34
Venus	15	14	− 17	46	17	47	− 24	22
Mars	15	46	− 20	20	17	16	− 23	47
Jupiter	15	4	− 16	26	15	30	− 18	7
Saturn	17	21	− 22	3	17	34	− 22	16
Uranus	16	18	− 21	19	16	26	− 21	38
Neptune	5	46	+ 22	7	5	43	+ 22	5



THE CONSTELLATIONS AT 9 P. M., NOVEMBER 1, 1899.

All six are evening stars at the beginning of the month, but none are visible to the eye except Saturn, and that only for a little while very early in the evening and at too low an altitude for satisfactory observations. Mercury will pass by Mars, going eastward, on Nov. 3, and Uranus Nov. 8; will reach greatest eastern elongation, 22° 27′ from the sun, Nov. 15, being visible as evening star in the southwest for perhaps a week; then on its return toward the sun will pass by Venus on the 26th and Mars on the 30th.

Venus will be in conjunction with Uranus on the 14th, with Mars on the 16th, with Mercury on the 26th and with Saturn on the 27th. Mars also will be in conjunction with Uranus on the 13th. Jupiter will be in conjunction with the Sun at the same time and Uranus will be in the same configuration on the 30th. Surely if conjunctions of planets ever have much effect upon the weather, this month ought to be a turbulent one.

The new moon will pass by the planets in the following order: Jupiter Nov. 3, 8:52 p. m., Venus Nov. 4, 6:53 a. m., Mars Nov. 4, 6:18 p. m., Mercury Nov. 4, 7:13 p. m., Uranus Nov. 5, 4:07 a. m. and Saturn Nov. 6, 5:55 a. m.

Neptune is all by its lone self on the other side of the heavens, and may be found after midnight among the faint stars nearly in line with and half way between ζ Tauri and η Geminorum.

Sunspots have been almost nil during the past month, the few seen being very minute.

COMET NOTES.

Comet *e* 1899 (Giacobini).—This comet we have not yet been able to see at Northfield, the few nights when we were at liberty to look it up being hazy in the west. The comet is reported to be faint, and the ephemerides show that it is growing fainter; having passed perihelion in July. The following elements and ephemeris were calculated by Misses Hobe, Kuno and Phipps, students of Professor A. O. Leuschner at the University of California, from observations on Oct. 2, 3 and 4.

ELEMENTS.

Perihelion time	$T =$ July 25.31 Greenwich M. T.
Perihelion minus node	$\omega = 327°\ 16'$
Longitude of node	$\Omega = 279\ \ 55$
Inclination	$i = \ 90\ \ 50$
Perihelion distance	$q = 1.3439$

EPHEMERIS.

		R. A. h m s	Decl. ° ′	Light
Oct.	8	16 41 12	− 2 24	0.84
	12	16 46 44	− 1 16	
	16	16 52 12	− 0 12	
	20	16 57 36	+ 0 49	0.60

Later elements have been received from Lick Observatory computed by Mr. C. D. Perrine from observations on Oct. 1, 7, and 16.

ELEMENTS BY PERRINE.

Perihelion time	$T =$ Sept. 15.04 Greenwich M. T.
Perihelion minus node	$\omega = 10°\ 52'$
Longitude of node	$\Omega = 272\ \ 13$
Inclination	$i = \ 76\ \ 55$
Perihelion distance	$q = 1.7854$

EPHEMERIS.

		R. A. h m s	Decl. ° ′	Light.
Oct.	24	17 5 8	+ 2 17	0.72
	28	17 11 12	+ 3 21	
Nov.	1	17 17 24	+ 4 25	
	5	17 23 26	+ 5 29	0.63

Elements and Ephemeris of Comet *e* 1899 (Giacobini.)

Using the Koenigsberg observations of October 1 and my own observations of the 7th and 16th I have obtained the following system of parabolic elements;

T	1899 September 15.0430 Greenwich M. T.	
ω	10° 51′ 55″.9	1899.0
Ω	272 12 32 1	
i	76 55 18.8	
log q	0.251754.	

Residuals, Obs.—Comp.

$\Delta\lambda' \cos\beta'$	+ 8″.9
$\Delta\beta'$	+ 1.8

Constants for the Equator of 1899.0.

$x = [9.360542]\, r \sin(\ 20° \ 32' \ 21''.4 + v)$
$y = [9.996607]\, r \sin(258 \ 22 \ 5.6 + v)$
$z = [9.991796]\, r \sin(346 \ 57 \ 15.4 + v)$

Ephemeris for 12^h Greenwich Mean Time.

1899		True α h m s	True δ ° ″	log Δ	Br.
Nov.	1.5	17 17 22	+ 4 24.7	0.386	0.66
	3.5	20 30	4 56.7		
	5.5	23 38	5 28.8	0.393	0.63
	7.5	26 48	6 0.9		
	9.5	29 58	6 33.1	0.399	0.60
	11.5	33 10	7 5.2		
	13.5	36 23	7 37.3	0.405	0.57
	15.5	39 37	8 9.5		
	17.5	42 52	8 41.8	0.410	0.55
	19.5	46 8	9 14.3		
	21.5	49 25	9 46.8	0.415	0.52
	23.5	52 44	10 19.6		
	25.5	56 3	10 52.6	0.420	0.50
	27.5	17 59 24	11 25.8		
	29.5	18 2 45	11 59.2	0.424	0.48
Dec.	1.5	6 8	12 32.6		
	3.5	18 9 32	+ 13 6.9	0.429	0.46

The unit of brightness is that on October 1.

C. D. PERRINE.

Lick Observatory, University of California,
1899 October 21.

Ephemeris of Holmes' Comet *d* 1899.—In *Astronomische Nachrichten* No. 3595, Mr. H. J. Zwiers gives a continuation of his ephemeris of this comet, extending to the end of the year. It is doubtful whether the comet will be visible for that length of time even with the largest telescopes, but the attempt should be made to follow it as far as possible.

Mr. Zwiers gives the brightness of the comet on two different assumptions: first, that it varies with the inverse square of the comet's distance from the sun only, $H_1 = r^{-2}$; second, that it varies with the product of the inverse squares of the distances from the sun and earth, $H_2 = (r\Delta)^{-2}$.

1899	H_1	H_2	1899	H_1	H_2
Oct. 3	0.17	0.06	Dec. 2	0.14	0.04
15	0.16	0.06	14	0.14	0.04
27	0.16	0.06	26	0.13	0.03
Nov. 8	0.15	0.06	32	0.13	0.03
20	0.15	0.05			

Ephemeris of Comet Holmes 1899 II (1899 *d*).

1899	α app. h m s	δ app. ° ′ ″	Aberr.	log Δ
Nov. 1	2 37 50.33	+ 49 14 55.4	0.00950	0.216458
2	36 36.67	49 14 8.0	00951	216826
3	35 23.08	49 12 57.8	00952	217253
4	34 9.70	49 11 24.8	00953	217739
5	32 56.63	49 9 29.5	00954	218284
6	31 44.00	49 7 12.1	00955	218888
7	30 31.92	49 4 33.0	00957	219552
8	29 20.51	49 1 32.6	00958	220274
9	28 9.89	48 58 11.4	00960	221056
10	27 0.16	48 54 29.8	00962	221896
11	25 51.41	48 50 28.4	00964	222795
12	24 43.76	48 46 7.7	00966	223751
13	23 37.30	48 41 28.3	00968	224766
14	22 32.11	48 36 30.7	00971	225837
15	21 28.27	48 31 15.7	00973	226965
16	20 25.87	48 25 43.7	00976	228150
17	19 24.98	48 19 55.4	00979	229390
18	18 25.68	48 13 51.5	00982	230685
19	17 28.03	48 7 32.5	00985	232035
20	16 32.09	48 0 59.3	00988	233438
21	15 37.93	47 54 12.3	00991	234895
22	14 45.60	47 47 12.4	00995	236405
23	13 55.17	47 40 0.2	00998	237966
24	13 6.67	47 32 36.4	01002	239579
25	12 20.16	47 25 1.7	01006	241242
26	11 35.67	47 17 16.9	01010	242954
27	10 53.25	47 9 22.5	01014	244715
28	10 12.94	47 1 19.5	01018	246523
29	9 34.75	46 53 8.4	01022	248379
30	8 58.72	46 44 50.0	01027	250280
Dec. 1	2 8 24.88	+ 46 36 25.1	0.01032	0.252226

GENERAL NOTES.

Our next number brings us to the close of the seventh volume of this publication. All contributors to that number will confer a favor by sending communications unusually early to give time for indexing so that we may publish, as usual, the index of this volume with its last number and not be delayed.

Observations of the November Leonids.—From what has been said in past numbers of this publication, and from the wide-spread interest felt generally in the coming display, we believe better results will be obtained, than ever

before, if the time for observation shall prove favorable, notwithstanding some unfavorable circumstances already spoken of definitely elsewhere in this number. It is hoped that observers will take great pains to plot the meteor trails on some suitable chart like those sent out from this office, and promptly send to us the same with such descriptive matter as is desirable that we may have data for a full and an early report in the forthcoming numbers of this publication.

Report of the Board of Visitors to the Naval Observatory.—We have printed elsewhere a full statement covering the points made in the report of the Board of Visitors appointed by Secretary Long to examine the condition of the United States Naval Observatory and to make such recommendations regarding the management of the same as should seem wise and best. The conclusions reached by the Board of Visitors and the recommendations offered in the report, after mature deliberation, seem to us very fair to all interests involved. They also suggest a plan of management of the Observatory which may prove successful if the same is carried out by a Secretary of the Navy uniformly of ability and purpose like those of the present incumbent. To Secretary Long is due much of the credit for steps in the right direction so far. We wish that it had seemed wise to this visiting board to recommend a change of name of the Observatory. The Board of Visitors well indicates the object and scope of this institution as national in character. Then why not call it a National Observatory? The word "Naval" is certainly not a proper designation.

Lunar Rainbow at Strait of Gibraltar.—I have just witnessed a display which seems of sufficiently rare occurrence to merit record in POPULAR ASTRONOMY. It is a *lunar rainbow*, not only somewhat rare in itself, but especially so in this case because of its great brightness and the fact that a faint secondary bow was present. I have been at Palermo and Naples visiting the scenes of Piazzi's labors and today reached Gibraltar en route to New York. All this day in port has been dreary and rainy. The clouds have been rolling in from the ocean to break with all force on the sides of this rocky fortress. At about 6:45 p. m. we got under way again. While passing near to the Spanish coast seeking the broad ocean, the moon, then about 35° degrees high, shed at 7 p. m. a burst of light through a rift in the clouds; and at once, in the west, appeared the spectrum bow. It seemed to almost span the space between Europe and Africa and form a triumphal arch under which our ship should pass onward upon the bosom of the deep. Brighter and brighter it grew with the moon's increasing light as cloud after cloud drifted from before her face, until at length, some 10° above the primary bow appeared the secondary. For fully seven minutes the two remained for the admiration of our passengers and then disappeared as the atmosphere cleared and the mist clouds descended as a gentle rain after which (and as I now write) the stars are appearing to replace the fading beams of the western most lighthouses. Only once before some eighteen years have I been privileged to see a rainbow formed by the moon. Others may have been more fortunate in this respect; but there have been probably few occasions when the phenomenon was more noticeable or more picturesque than on this evening, when the waters are all around and above and below us, and the gilt band of God's promise of peace links two continents in its embrace in spite of the warring of a nation in one against two almost helpless peoples in the other, and while at one end of the bow lies a nation just punished by a sword of vengeance. May it augur returning

prosperity to the last, and the best good to the greatest number in the case of former.

HERMAN S. DAVIS.

408 West 124th St., New York City.

Teachers of Geometry and Astronomy.—We have printed two articles in this number to which special attention is asked on the part of teachers of the elements of Geometry and Astronomy. We have nowhere seen a more terse, sensible and philosophically suggestive statement of method for teaching the elements of astronomy than that given elsewhere in this issue by a prominent instructor in a state normal school under the title of "Astronomy by the Laboratory Method in Secondary Schools." This author has prepared a pamphlet of 40 pages for use in his own classes in which he gives his method of work in this branch of study, and it shows plainly to our mind that he has very earnestly and very well considered best ways and means to success as an instructor. One could but expect large results under such circumstances. The other article is a copy from a late number of Science prepared by Professor George Bruce Halsted who, not long ago, was asked by the American Association for the Advancement of Science to prepare a report which was given at its last August meeting showing recent progress in non-Euclidean Geometry. Professor Halsted has done the teachers of the elements of Geometry in all schools most excellent service in the preparation of this paper, the first part of which we can only give at this time. We call attention to this early, that teachers, thus disposed, may read it thoroughly, so as to be acquainted with the points in the present lively discussion that is now going on among the masters in pure mathematics. The information gained will be helpful to those who want to be abreast with the best teaching talent of the present time.

Relation Between Clock Rate and Barometric Pressure.—We have received a thoughtful paper from Ensign E. Hayden, United States Navy, printed in the Publications of the Astronomical Society of the Pacific, No. 68, which is an investigation to determine the effect of barometric pressure on the rate of an astronomical time-piece. The observations were made at Mare Island Observatory, where time observations are taken regularly for the rating of chronometers to be used by the Navy. Observations were made on the Mean Time clock of the Observatory and three chronometers of the Negus make. The plan was to read the four time-pieces under varying pressure shown by the barometer and for temperature, and to tabulate the results for a period of two hundred days and then represent the changes for the period by a curve. After the work was completed the author thinks that if he had depended on his rate curve without any time observations the noon signal would not have been in error at any time more than six-tenths of a second and usually not more than one-tenth, and at the end of the period of 200 days the error would have been only a few hundredths of a second. These barometric and temperature curves are now used in the work of the Observatory largely, and the writer of this paper thinks that a good pendulum clock will keep much better time if these curves are used than may have been generally supposed. He also thinks that this method may be applied to time-keeping of chronometers when in use at sea. The chronometers employed in these observations are to be tested this way and it is certain that keepers of astronomical time will be interested in the results.

Not long ago an effort was made at this Observatory to determine the same

thing by observations on the Howard Gravity Escapement clock No. 195, running in Sidereal time, for a period of a whole year. The results obtained by this series of observations were unsatisfactory.

Jupiter's Fifth Satellite.—Professor E. E. Barnard, of the Yerkes Observatory, Williams Bay, Wis., has determined the revolution period of the fifth satellite to the planet Jupiter, during the last two apparitions of the planet very closely, by the aid of the great 40-inch refractor. The result of work done at Lick Observatory and at Yerkes Observatory gives a period of revolution of this satellite of $11^h\ 57^m\ 22^s.647$ which is not in error more than $0^s.01$. The detail work leading to this result shows the accuracy possible in good micrometric work when done by the aid of a large refractor. Professor Barnard has done admirable work with the micrometer on most difficult objects.

Tables of Uranus.—A copy of the tables of Uranus by Professor S. Newcomb, and published by the authority of Congress has been received. This paper consisting of 125 pages is part III of Vol. VII of the astronomical papers prepared by the same author. The series of volumes is invaluable to practical astronomy, and the Board of Visitors to the Naval Observatory in reporting in favor of the continuance of this strictly professional work did a timely and a wise thing. From the preface and the full introduction to these tables of the heliocentric motion of the planet Uranus, we learn some things that will interest some of our readers, especially those who are unacquainted with this kind of professional study. These tables "are based on elements derived from meridian observations of the planet, from the time of its discovery by Herschel in 1781 to the opposition of 1898. The outstanding residuals between theory and observation, left in the solution of the equations, sometimes amount to one second of arc. It is not possible at the present time to decide whether these differences are real or whether they arise from the errors of the ephemeris of comparison, which, between 1830 and 1872, was that derived from Bonvard tables. The observations since 1860 seem to be represented with great exactness."

From the introduction it appears that these tables are based on an investigation which has not yet been published, and that the perturbations have been, for the most part, recomputed, and the elements determined from the best available observations including those of the opposition of 1897-1898. The elements are also corrected for secular variations and inequalities of long period covering about 4,200 years, on account of the fact that the mean motion of Uranus is nearly twice that of Neptune. The epoch of these new tables is 1900 January 0, Greenwich Mean Noon. There are many other interestirg data in the thirty pages of introduction preceding the tables that will repay perusal by those who wish the best in this line of practical astronomy.

Orbit of Planet (433) Eros.—In the last number of the *Astronomische Nachrichten* (3597) Mr. Hans Osten of Bremen gives a new determination of the orbit of this interesting planet. He has compared all the available observations from Aug. 14, 1898 to Jan. 10, 1899, with an ephemeris calculated from Professor Millosevich's elements in *Astronomische Nachrichten* No. 3528, forming from them six normal places of the planet. Later observations, in February and March 1899, at Strasburg, compared with improved elements gave two new normal places. From the eight normal place the following elements were obtained:

Epoch and Osculation Oct 10, 1898, Berlin Mean Time.

$$\left.\begin{array}{rrrrr} M = & 238^\circ & 39' & 44''.64 \pm & 15''.84 \\ \omega = & 177 & 39 & 21.05 \pm & 15.24 \\ \Omega = & 303 & 31 & 53.37 \pm & 2.62 \\ i = & 10 & 49 & 33\ 99 \pm & 0.52 \\ \varphi = & 12 & 52 & 18\ 33 \pm & 2.63 \end{array}\right\} 1900.0$$

$$\mu = 2015''.34326 \pm 0''.07250$$

These elements represent all normal places closely, the largest deviation being 1″.78 and the average error being less than 1″.

The following equatorial coördinates referred to the equator of 1900.0 will be useful to those who wish to compute ephemerides:

$$\begin{aligned} x &= [9.9946103]\, r.\ \sin\ (v + 211^\circ\ 39'\ 45''.96) \\ y &= [9.9414672]\, r.\ \sin\ (v + 116\ \ 36\ \ 14.88) \\ z &= [9.7081486]\, r.\ \sin\ (v + 137\ \ 8\ \ 31.73) \end{aligned}$$

A Long Photographic Telescope.—Last spring a plan was proposed at the Harvard College Observatory for the construction of a telescope of unusual length for photographing the stars and planets Anonymous donors have now furnished the means by which this experiment may be tried. This plan will, therefore, take definite shape, and it is expected that a telescope having an aperture of 12 inches and a length of a hundred feet or more will be ready for trial at Cambridge in a few weeks. EDWARD C. PICKERING.

HARVARD COLLEGE OBSERVATORY, 1899, October 12.

Heat Radiation of the Stars.—In an important paper published in 1890* Professor C. V. Boys describes his unsuccessful attempts to detect heat radiations from the stars by means of an exceedingly delicate radiometer used in conjunction with a 16 inch reflecting telescope. In spite of the fact that his apparatus was sensitive enough to show the heat equivalent to that of a candle 1.71 miles away, no effect whatever could be obtained from Venus, Jupiter, Saturn, Mars, Arcturus, Capella, Vega, or any of the numerous bright stars observed. After discussing the earlier papers of Huggins† and Stone,‡ Professor Boys concludes that the heating effects of stars, obtained many years ago by these observers with comparatively insensitive apparatus, were spurious.

The work of Dr. E. F. Nichols, Professor of Physics in Dartmouth College, in perfecting the radiometer, and adapting it for the measurement of heat radiations, has placed astrophysicists in posession of an instrument which for certain purposes is superior to the radiomicrometer, bolometer, or most improved form of thermopile. In view of the remarkable sensitiveness of the radiometer and its suitability for stellar work, Professor Nichols was invited to make an attempt to detect stellar heat radiations with its aid at the Yerkes Observatory. The investigation was accordingly undertaken in July 1898.

The experiments were made in the heliostat room of the Yerkes Observatory, where the radiometer, stably mounted upon a heavy pier could be shielded from air currents and other sources of disturbance. The great steadiness of the reflected image of the scale, making it possible to record deflections to tenths of a millimeter, was doubtless due to this arrangement.

The radiometer, constructed by Professor Nichols especially for these experiments, essentially consists of a suspension system formed of two mica disks,

* Proceedings of the Royal Society, 47, 480, 1890.
† Ibid., 17, 309, 1869. ‡ Ibid., 18, 159, 1870.

before, if the time for observation shall prove favorable, notwithstanding some unfavorable circumstances already spoken of definitely elsewhere in this number. It is hoped that observers will take great pains to plot the meteor trails on some suitable chart like those sent out from this office, and promptly send to us the same with such descriptive matter as is desirable that we may have data for a full and an early report in the forthcoming numbers of this publication.

Report of the Board of Visitors to the Naval Observatory.—We have printed elsewhere a full statement covering the points made in the report of the Board of Visitors appointed by Secretary Long to examine the condition of the United States Naval Observatory and to make such recommendations regarding the management of the same as should seem wise and best. The conclusions reached by the Board of Visitors and the recommendations offered in the report, after mature deliberation, seem to us very fair to all interests involved. They also suggest a plan of management of the Observatory which may prove successful if the same is carried out by a Secretary of the Navy uniformly of ability and purpose like those of the present incumbent. To Secretary Long is due much of the credit for steps in the right direction so far. We wish that it had seemed wise to this visiting board to recommend a change of name of the Observatory. The Board of Visitors well indicates the object and scope of this institution as national in character. Then why not call it a National Observatory? The word "Naval" is certainly not a proper designation.

Lunar Rainbow at Strait of Gibraltar.—I have just witnessed a display which seems of sufficiently rare occurrence to merit record in POPULAR ASTRONOMY. It is a *lunar rainbow*, not only somewhat rare in itself, but especially so in this case because of its great brightness and the fact that a faint secondary bow was present. I have been at Palermo and Naples visiting the scenes of Piazzi's labors and today reached Gibraltar en route to New York. All this day in port has been dreary and rainy. The clouds have been rolling in from the ocean to break with all force on the sides of this rocky fortress. At about 6:45 p. m. we got under way again. While passing near to the Spanish coast seeking the broad ocean, the moon, then about 35° degrees high, shed at 7 p. m. a burst of light through a rift in the clouds; and at once, in the west, appeared the spectrum bow. It seemed to almost span the space between Europe and Africa and form a triumphal arch under which our ship should pass onward upon the bosom of the deep. Brighter and brighter it grew with the moon's increasing light as cloud after cloud drifted from before her face, until at length, some 10° above the primary bow appeared the secondary. For fully seven minutes the two remained for the admiration of our passengers and then disappeared as the atmosphere cleared and the mist clouds descended as a gentle rain after which (and as I now write) the stars are appearing to replace the fading beams of the western most lighthouses. Only once before some eighteen years have I been privileged to see a rainbow formed by the moon. Others may have been more fortunate in this respect; but there have been probably few occasions when the phenomenon was more noticeable or more picturesque than on this evening, when the waters are all around and above and below us, and the gilt band of God's promise of peace links two continents in its embrace in spite of the warring of a nation in one against two almost helpless peoples in the other, and while at one end of the bow lies a nation just punished by a sword of vengeance. May it augur returning

prosperity to the last, and the best good to the greatest number in the case of former.

HERMAN S. DAVIS.

408 West 124th St., New York City.

Teachers of Geometry and Astronomy.—We have printed two articles in this number to which special attention is asked on the part of teachers of the elements of Geometry and Astronomy. We have nowhere seen a more terse, sensible and philosophically suggestive statement of method for teaching the elements of astronomy than that given elsewhere in this issue by a prominent instructor in a state normal school under the title of "Astronomy by the Laboratory Method in Secondary Schools." This author has prepared a pamphlet of 40 pages for use in his own classes in which he gives his method of work in this branch of study, and it shows plainly to our mind that he has very earnestly and very well considered best ways and means to success as an instructor. One could but expect large results under such circumstances. The other article is a copy from a late number of Science prepared by Professor George Bruce Halsted who, not long ago, was asked by the American Association for the Advancement of Science to prepare a report which was given at its last August meeting showing recent progress in non-Euclidean Geometry. Professor Halsted has done the teachers of the elements of Geometry in all schools most excellent service in the preparation of this paper, the first part of which we can only give at this time. We call attention to this early, that teachers, thus disposed, may read it thoroughly, so as to be acquainted with the points in the present lively discussion that is now going on among the masters in pure mathematics. The information gained will be helpful to those who want to be abreast with the best teaching talent of the present time.

Relation Between Clock Rate and Barometric Pressure.—We have received a thoughtful paper from Ensign E. Hayden, United States Navy, printed in the Publications of the Astronomical Society of the Pacific, No. 68, which is an investigation to determine the effect of barometric pressure on the rate of an astronomical time-piece. The observations were made at Mare Island Observatory, where time observations are taken regularly for the rating of chronometers to be used by the Navy. Observations were made on the Mean Time clock of the Observatory and three chronometers of the Negus make. The plan was to read the four time-pieces under varying pressure shown by the barometer and for temperature, and to tabulate the results for a period of two hundred days and then represent the changes for the period by a curve. After the work was completed the author thinks that if he had depended on his rate curve without any time observations the noon signal would not have been in error at any time more than six-tenths of a second and usually not more than one-tenth, and at the end of the period of 200 days the error would have been only a few hundredths of a second. These barometric and temperature curves are now used in the work of the Observatory largely, and the writer of this paper thinks that a good pendulum clock will keep much better time if these curves are used than may have been generally supposed. He also thinks that this method may be applied to time-keeping of chronometers when in use at sea. The chronometers employed in these observations are to be tested this way and it is certain that keepers of astronomical time will be interested in the results.

Not long ago an effort was made at this Observatory to determine the same

thing by observations on the Howard Gravity Escapement clock No. 195, running in Sidereal time, for a period of a whole year. The results obtained by this series of observations were unsatisfactory.

Jupiter's Fifth Satellite.—Professor E. E. Barnard, of the Yerkes Observatory, Williams Bay, Wis., has determined the revolution period of the fifth satellite to the planet Jupiter, during the last two apparitions of the planet very closely, by the aid of the great 40-inch refractor. The result of work done at Lick Observatory and at Yerkes Observatory gives a period of revolution of this satellite of $11^h\ 57^m\ 22^s.647$ which is not in error more than $0^s.01$. The detail work leading to this result shows the accuracy possible in good micrometric work when done by the aid of a large refractor. Professor Barnard has done admirable work with the micrometer on most difficult objects.

Tables of Uranus.—A copy of the tables of Uranus by Professor S. Newcomb, and published by the authority of Congress has been received. This paper consisting of 125 pages is part III of Vol. VII of the astronomical papers prepared by the same author. The series of volumes is invaluable to practical astronomy, and the Board of Visitors to the Naval Observatory in reporting in favor of the continuance of this strictly professional work did a timely and a wise thing. From the preface and the full introduction to these tables of the heliocentric motion of the planet Uranus, we learn some things that will interest some of our readers, especially those who are unacquainted with this kind of professional study. These tables "are based on elements derived from meridian observations of the planet, from the time of its discovery by Herschel in 1781 to the opposition of 1898. The outstanding residuals between theory and observation, left in the solution of the equations, sometimes amount to one second of arc. It is not possible at the present time to decide whether these differences are real or whether they arise from the errors of the ephemeris of comparison, which, between 1830 and 1872, was that derived fron Bonvard tables. The observations since 1860 seem to be represented with great exactness."

From the introduction it appears that these tables are based on an investigation which has not yet been published, and that the perturbations have been, for the most part, recomputed, and the elements determined from the best available observations including those of the opposition of 1897-1898. The elements are also corrected for secular variations and inequalities of long period covering about 4,200 years, on account of the fact that the mean motion of Uranus is nearly twice that of Neptune. The epoch of these new tables is 1900 January 0, Greenwich Mean Noon. There are many other interesting data in the thirty pages of introduction preceding the tables that will repay perusal by those who wish the best in this line of practical astronomy.

Orbit of Planet (433) Eros.—In the last number of the *Astronomische Nachrichten* (3597) Mr. Hans Osten of Bremen gives a new determination of the orbit of this interesting planet. He has compared all the available observations from Aug. 14, 1898 to Jan. 10, 1899, with an ephemeris calculated from Professor Millosevich's elements in *Astronomische Nachrichten* No. 3528, forming from them six normal places of the planet. Later observations, in February and March 1899, at Strasburg, compared with improved elements gave two new normal places. From the eight normal place the following elements were obtained:

Epoch and Osculation Oct 10, 1898, Berlin Mean Time.

$$\left.\begin{array}{lrrrr} M = & 238° & 39' & 44''.64 \pm & 15''.84 \\ \omega = & 177 & 39 & 21.05 \pm & 15.24 \\ \Omega = & 303 & 31 & 53.37 \pm & 2.62 \\ i = & 10 & 49 & 33\ 99 \pm & 0.52 \\ \varphi = & 12 & 52 & 18\ 33 \pm & 2.63 \end{array}\right\} 1900.0$$

$$\mu = 2015''.34326 \pm 0''.07250$$

These elements represent all normal places closely, the largest deviation being 1″.78 and the average error being less than 1″.

The following equatorial coördinates referred to the equator of 1900.0 will be useful to those who wish to compute ephemerides:

$$\begin{array}{lrrr} x = [9\ 9946103]\ r.\ \sin (v + & 211° & 39' & 45''.96) \\ y = [9\ 9414672]\ r.\ \sin (v + & 116 & 36 & 14.88) \\ z = [9.7081486]\ r.\ \sin (v + & 137 & 8 & 31.73) \end{array}$$

A Long Photographic Telescope.—Last spring a plan was proposed at the Harvard College Observatory for the construction of a telescope of unusual length for photographing the stars and planets Anonymous donors have now furnished the means by which this experiment may be tried. This plan will, therefore, take definite shape, and it is expected that a telescope having an aperture of 12 inches and a length of a hundred feet or more will be ready for trial at Cambridge in a few weeks. EDWARD C. PICKERING.

HARVARD COLLEGE OBSERVATORY, 1899, October 12.

Heat Radiation of the Stars.—In an important paper published in 1890* Professor C. V. Boys describes his unsuccessful attempts to detect heat radiations from the stars by means of an exceedingly delicate radiometer used in conjunction with a 16-inch reflecting telescope. In spite of the fact that his apparatus was sensitive enough to show the heat equivalent to that of a candle 1.71 miles away, no effect whatever could be obtained from Venus, Jupiter, Saturn, Mars, Arcturus, Capella, Vega, or any of the numerous bright stars observed. After discussing the earlier papers of Huggins† and Stone,‡ Professor Boys concludes that the heating effects of stars, obtained many years ago by these observers with comparatively insensitive apparatus, were spurious.

The work of Dr. E. F. Nichols, Professor of Physics in Dartmouth College, in perfecting the radiometer, and adapting it for the measurement of heat radiations, has placed astrophysicists in posession of an instrument which for certain purposes is superior to the radiomicrometer, bolometer, or most improved form of thermopile. In view of the remarkable sensitiveness of the radiometer and its suitability for stellar work, Professor Nichols was invited to make an attempt to detect stellar heat radiations with its aid at the Yerkes Observatory. The investigation was accordingly undertaken in July 1898.

The experiments were made in the heliostat room of the Yerkes Observatory, where the radiometer, stably mounted upon a heavy pier could be shielded from air currents and other sources of disturbance. The great steadiness of the reflected image of the scale, making it possible to record deflections to tenths of a millimeter, was doubtless due to this arrangement.

The radiometer, constructed by Professor Nichols especially for these experiments, essentially consists of a suspension system formed of two mica disks,

* Proceedings of the Royal Society, 47, 480, 1890.
† Ibid., 17, 309, 1869. ‡ Ibid., 18, 159, 1870.

each 2 mm in diameter, blackened on one face, and supported by a light cross-arm on either side of a thin glass staff, hung by an exceedingly fine quartz fiber in a partial vacuum. Both vanes were exposed to the radiation of the sky, at the focus of a silvered glass mirror of 24 inches aperture and 8 feet focus, made by Mr. G. W. Ritchey, Optician of the Yerkes Observatory. Rays from the star were reflected into the concave mirror by means of a siderostat* having a large plane mirror of silvered glass. After reflection at the concave mirror and also at the surface of a small flat fixed at an angle of 45° with the optical axis, the rays entered the radiometer through a fluorite window.

With this apparatus a deflection of 0.1 mm would be given by a candle 15 miles away, assuming total reflection at the silvered surfaces and neglecting atmospheric absorption. When the Moon's image is made to fall on one of the vanes, the scale is instantly thrown out of the field of view. Professor Nichols' radiometer is about five times as sensitive as Boys' radiometer, and the area of his telescope mirror is 2.4 times that of the mirror used by Boys. In Professor Nichol's apparatus there is, however, one additional reflection.

Seven determinations of the heat radiation of Arcturus, made on August 4, 5, 7, 8, 9, 11 and 13, give a mean deflection of 0.60 mm. Each evening's determination is the result of from 21 to 47 deflections, and the probable error of the corresponding means ranges from 0.08 mm to 0.17 mm. Vega was also observed on seven nights, and gave a mean deflection of 0.27 mm. The ratio of the heat radiation of Arcturus to that of Vega, determined on five nights, is 2.1, 2 0, 3.0, 2.3, 1.0† Mean 2.1. These results are not corrected for atmospheric absorption.

In all cases the observer was ignorant of the probable direction of the deflection, and other precautions were taken to avoid bias. The results appear to be trustworthy, and the probable errors are not greater than might be expected in such observations. In view of the smallness of the deflections and the uncertainty which arises from the rapid fluctuations in the atmosphere, Professor Nichols does not greatly rely upon the quantitative value of the results. They may fairly be considered to show, however, that we do not receive from Arcturus more heat than would reach us from a candle at a distance of five or six miles, no account being taken in the latter case of atmospheric absorption.

YERKES OBSERVATORY, Bulletin No. 11. GEORGE E. HALE.

Position of Nova Sagittarii.—The method of determining the precise positions of the stars from measures of their photographic images, described in the Annals, Volume XXVI, p. 237, is now generally employed here when accurate positions are desired. The positions of the planet Eros on the photographs described in Circulars Nos. 36 and 37 are being determined by this method. As an illustration of the accuracy readily attained, measures were made of the New Star in Sagittarius described in Circular No. 42. The first pair of plates measured were enlargements of Plate B 21319, taken with the 8-inch Bache telescope on April 29, 1898, with an exposure of 10 minutes. The star was then of the eighth magnitude. The second pair of plates were enlargements of Plate C 11827, taken with the 11-inch Draper telescope on March 20, 1899, when the star was of the eleventh magnitude. Six exposures of 10 minutes each were given to the last plate, moving it slightly in declination after each. Six adjacent images of the Nova and of each of the comparison stars were thus obtained. A single enlargement, therefore, furnishes six independent determinations of the position of the Nova. It was found more convenient, however, to

* Kindly loaned by the Allegheny Observatory.
† Sky very hazy.

take the mean of the measures of the six images and treat them like a single observation. Two enlargements were made of each of the two original negatives, taking care to move the recticule about a millimetre in each coördinate after the first enlargement of each plate, and thus eliminate, or at least reduce, errors in ruling. Four independent determinations of position are thus obtained, which are given below. Two positions of this object have been published, derived from visual observations. The first, by Professor O. C. Wendell, is given in Circular No. 42; the second, by Professor E. Hartwig, is given in the Astron. Nach. 149, 29. It should be stated that in the first of these determinations the times were noted on a chronometer by a comparatively inexperienced recorder, and in the second case, a single comparison star, — 13°5194, was used whose position was taken from Weisse, and differs several seconds from the recent observations of its position made here. The photographic determinations depend on the positions of five stars, — 13°5183, — 13°5185, — 13°5194, — 13°5197, and — 13°5200, measured with the Harvard Meridian Circle.

		h	m	s		°	′	″
Wendell.	R. A. 1900 =	18	56	12.2	Decl. 1900 =	— 13	18	16
Hartwig.	" " =	18	56	12.69	" " =	— 13	18	22.3
B 21319, I.	" " =	18	56	12.82	" " =	— 13	18	12.6
" II.	" " =	18	56	12.90	" " =	— 13	18	12.8
C 11827, I.	" " =	18	56	12.81	" " =	— 13	18	13.2
" II.	" " =	18	56	12.79	" " =	— 13	18	13.3

The close agreement of the four photographic measures indicates that this method gives results of an accuracy at least equal to the best meridian circle observations. As in the case of other Novae, there is no evidence of proper motion, or change of position as the star fades.

Several measures were made of each image of the Nova. A comparison of them shows that the probable error of a single setting is ± 0″.13, the largest residual being 0″.3. A similar determination from settings of the comparison stars gave the probable error derived from successive settings ± 0″.08. In three cases only did successive settings differ more than half a second, and these gave the values, 1″.0, 0″.7 and 0″.6.

The results of the first measures of the position of the Nova, as derived from the six images of Plate C 11827, and expressed in seconds of arc, differ from their mean in x by + 0″.02, — 0″.08, — 0″.38, + 0″.09, + 0″.27, and + 0″.07, and in y by — 0″.48, — 0″ 32, + 0″.18, + 0″.36, — 0″.08, and + 0″.26. The second measures similarly gave in x, — 0″.28, + 0″.03, — 0″.01, + 0″.06, + 0″.35, and — 0″.09, and in y, —0″.45, + 0″.03, + 0″.12, + 0″.19, — 0″.08, and + 0″.14. A part of these differences is real and is perhaps due to a change in orientation of the plate when it was moved. Thus, the largest value, — 0″.48, has nearly the same value, — 0″.45, in the second measure. The designations of the five comparison stars, their assumed right ascensions and declinations for 1890, and their residuals in x and y, as derived from the two measures of the two plates, are given below.

DM.	R. A. 1890.	Decl. 1890.	x				y			
°	h m s	° ′ ″	″	″	″	″	″	″	″	″
— 13 5183	18 54 58.19	— 13 8 36.4	+ 0.1	+ 0.2	— 0.1	— 0.3	— 0.4	+ 0.3	+ 0.2	+ 0.2
— 13 5185	18 55 1.90	— 13 28 31.1	+ 0.2	— 0.1	+ 0.5	— 0.1	— 1.5	— 1.2	— 0.6	— 0.6
— 13 5194	18 56 1.58	— 13 24 37.6	— 0.3	+ 0.3	+ 1.1	+ 1.3	+ 3.2	+ 2.7	+ 1.6	+ 1.6
— 13 5197	18 56 26.58	— 13 19 8.0	— 1.8	— 1.8	— 2.0	— 1.8	— 1.4	— 1.1	— 1.4	— 1.3
— 13 5200	18 56 41.60	— 13 19 25.1	+ 1.7	+ 1.4	+ 0.4	+ 0.7	— 0.7	— 0.5	+ 0.3	+ 0.2

EDWARD C. PICKERING.

HARVARD COLLEGE OBSERVATORY, Circular No. 46.
September 23, 1899.

Harvard College Observatory System of Registration.—Owing to the constantly increasing number of letters received at this Observatory from persons desiring situations in observatories and other astronomical and physical institutions, and from officers of institutions, seeking suitable persons to fill such positions, it has been decided to establish a uniform system of registration to be maintained for the benefit of astronomers and physicists.

The object of the system is to assist in bringing together institutions and candidates for positions without expense to either party. The Observatory does not recommend applicants, and assumes no responsibility for the character or ability of persons who may secure situations through its assistance, neither does it undertake to find positions for those whose names are submitted for registration. Forms of application will be furnished to any who may desire them, and when returned, properly filled, will be filed for future reference. Upon receipt of an application for a person to fill a given position, a list of names will be furnished of persons who, in the judgment of the Observatory will be most likely to be suited to the place. EDWARD C. PICKERING.

Cambridge, Mass., Sept. 11, 1899.

PUBLISHER'S NOTICES.

Contributors are asked to prepare copy carefully, and write *all proper names very plainly*. If other language than the English is used to any considerable extent it should be type-written. Manuscript to be returned should be accompanied by postage for that purpose.

All Drawings for publication should be done in India ink, twice the size that the cut will be on the printed page. The lines, figures and letters should be made even, very smooth and uniformly black in every part of the copy, in order to secure the best reproductions possible by the modern quick processes of engraving now most generally used.

Proofs will generally be sent to authors living in the United States, if copy is furnished before the tenth of the month preceding that of publication. We greatly prefer that authors should read their own proofs, and we will faithfully see that all corrections are made in the final proofs.

Renewals.—Notices of expiration of subscription will hereafter be sent with the last number of this publication for which payment has been made. It is especially requested that subscribers fill out the blank notice sent them and promptly return it to the publisher, as this publication will not be continued beyond the time for which it has been ordered.

Messrs. Wm. Wesley & Son, 28 Essex Street, Strand, London, England, are our sole European agents.

Reprints of articles for authors, when desired, will be furnished in titled paper covers at small cost. Persons wanting reprints should always notify the publisher when the copy is sent or the proof returned. For they can not be furnished later without incurring much greater expense.

Subscription Price to Popular Astronomy in the United States, Canada and Mexico is $2 50 per volume of 10 consecutive numbers. Price per volume of 10 numbers to foreign subscribers $3 00.

All correspondence and all remittances should be sent to

WM. W. PAYNE,
Northfield, Minn., U. S. A.

PLATE XII.

N

E W

S

The Great Andromeda Nebula.

From a Photograph by Dr. H. C. Wilson, with the 8-inch Clark Refractor of Goodsell Observatory of Carleton College, Northfield, Minn., Oct. 4, 5, 6 and 7, 1899. Total exposure 12^h. Enlarged 1.66 times from the original.